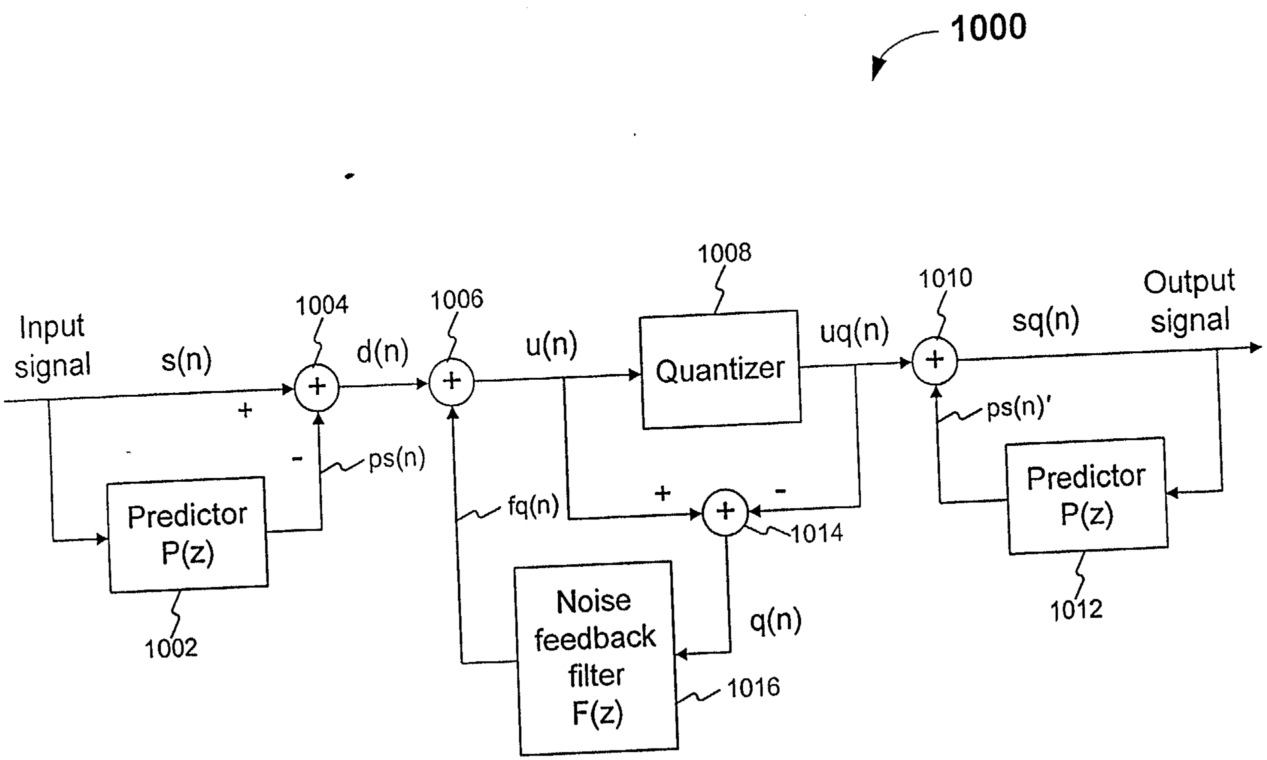


Figure 1 Conventional Noise Feedback Coding

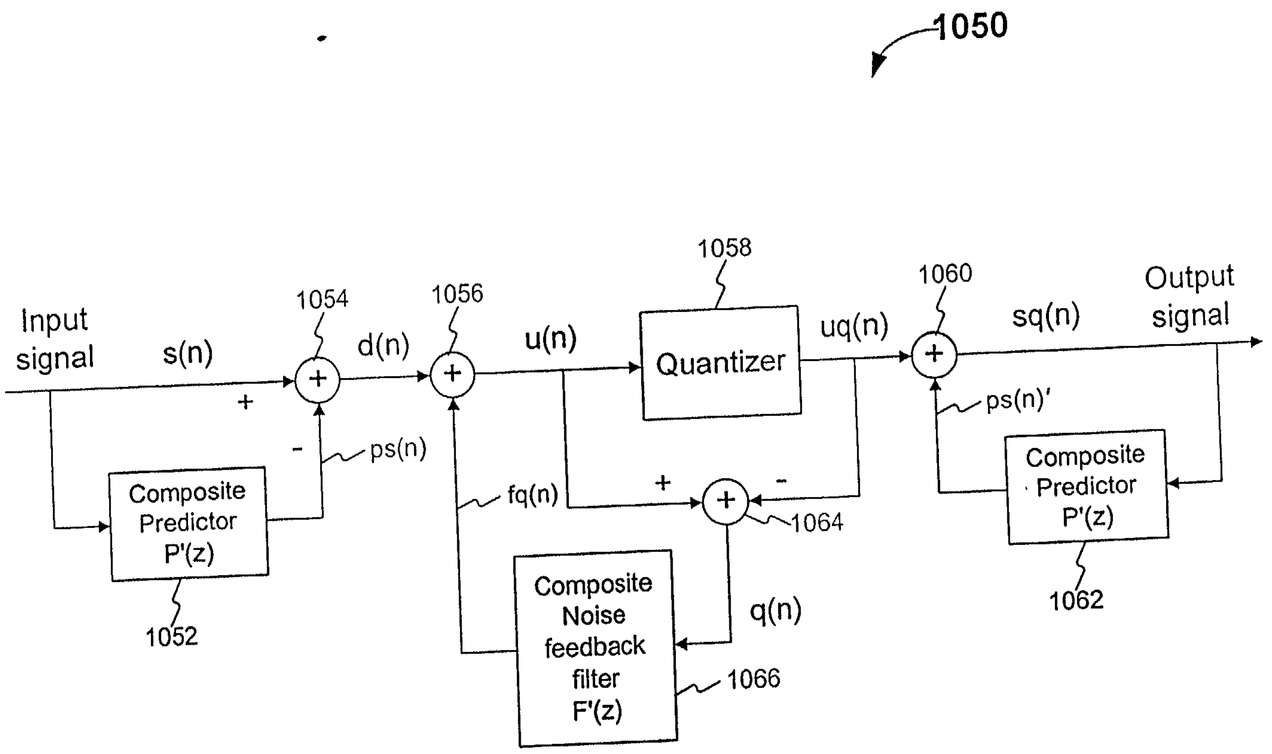


Figure 1A Noise Feedback Coding Using Composite Short-Term and Long-Term Predictors and Composite Short-Term and Long-Term Filter

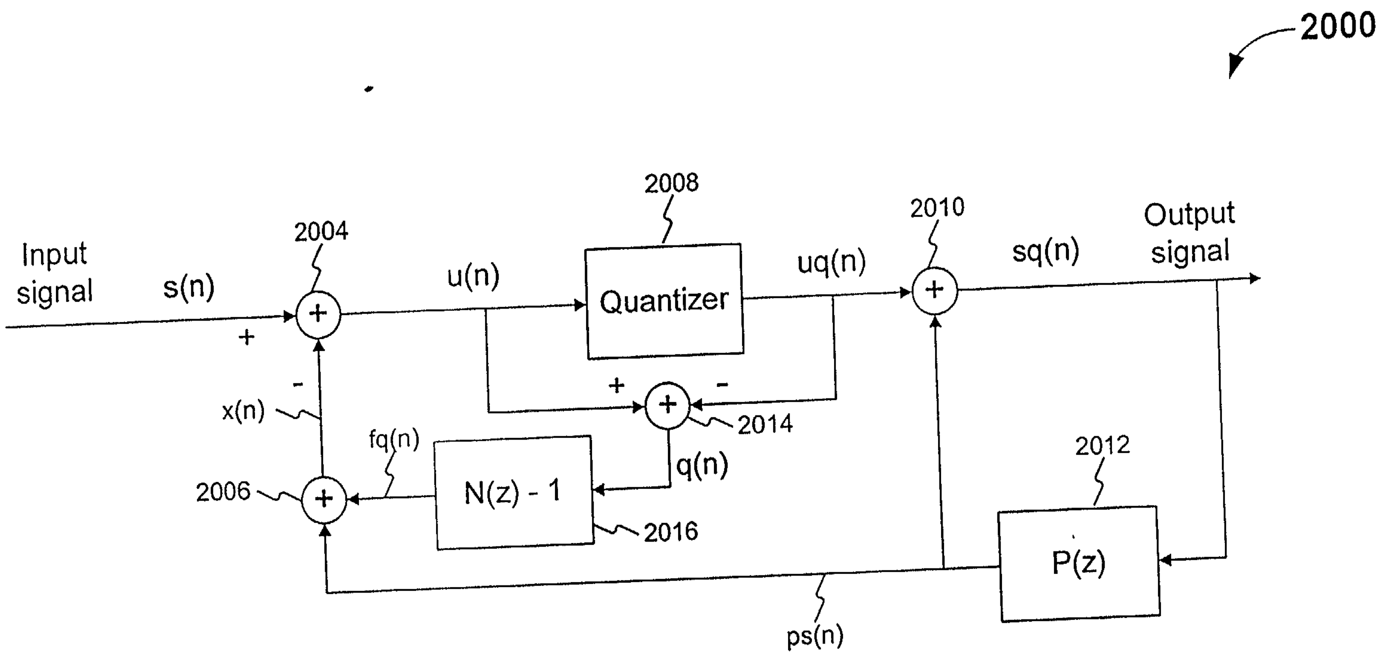


Figure 2 An alternative form of conventional Noise Feedback Coding

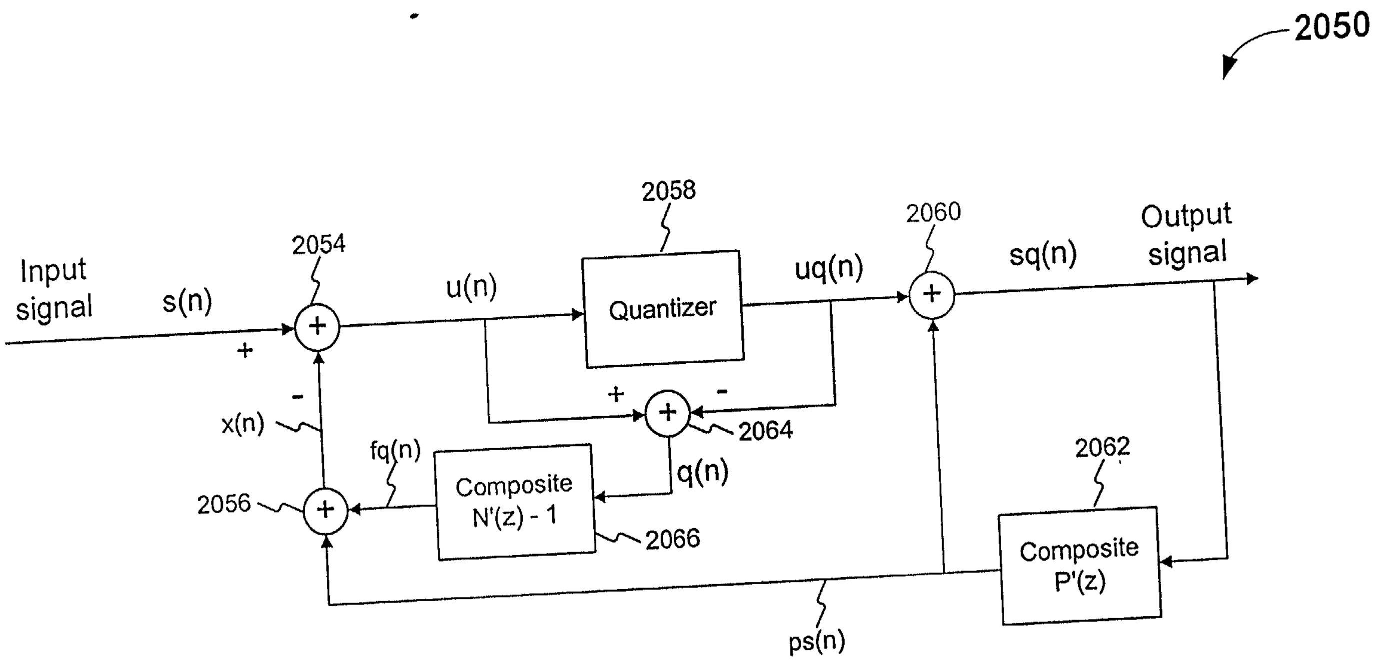


Figure 2A Noise Feedback Coding Using Composite Predictor and Composite Noise Filter

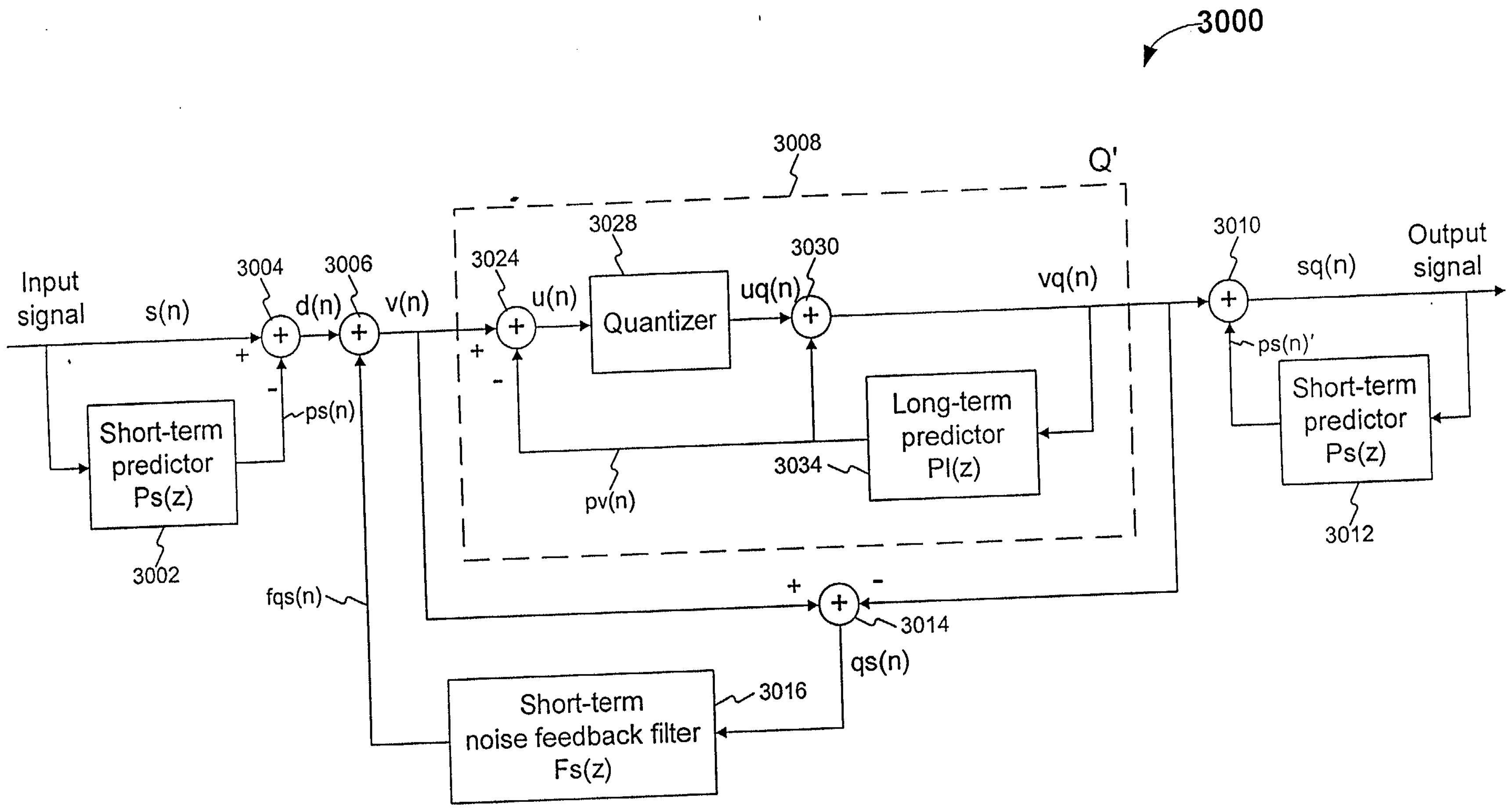


Figure 3 Noise Feedback Coding with short-term and long-term prediction but only short-term noise spectral shaping

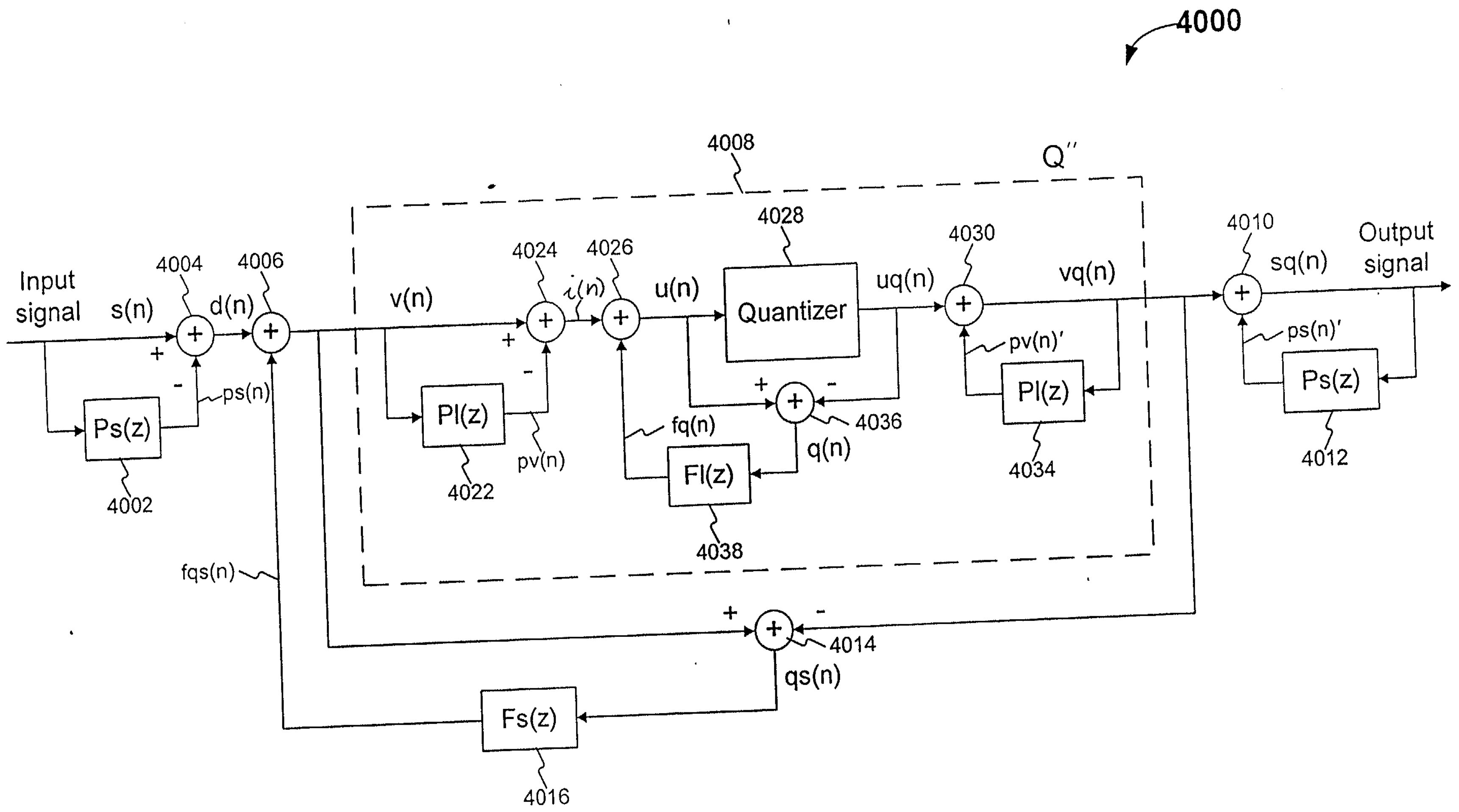


Figure 4 Nested two-stage Noise Feedback Coding structure with short-term and long-term prediction and short-term and long-term noise spectral shaping

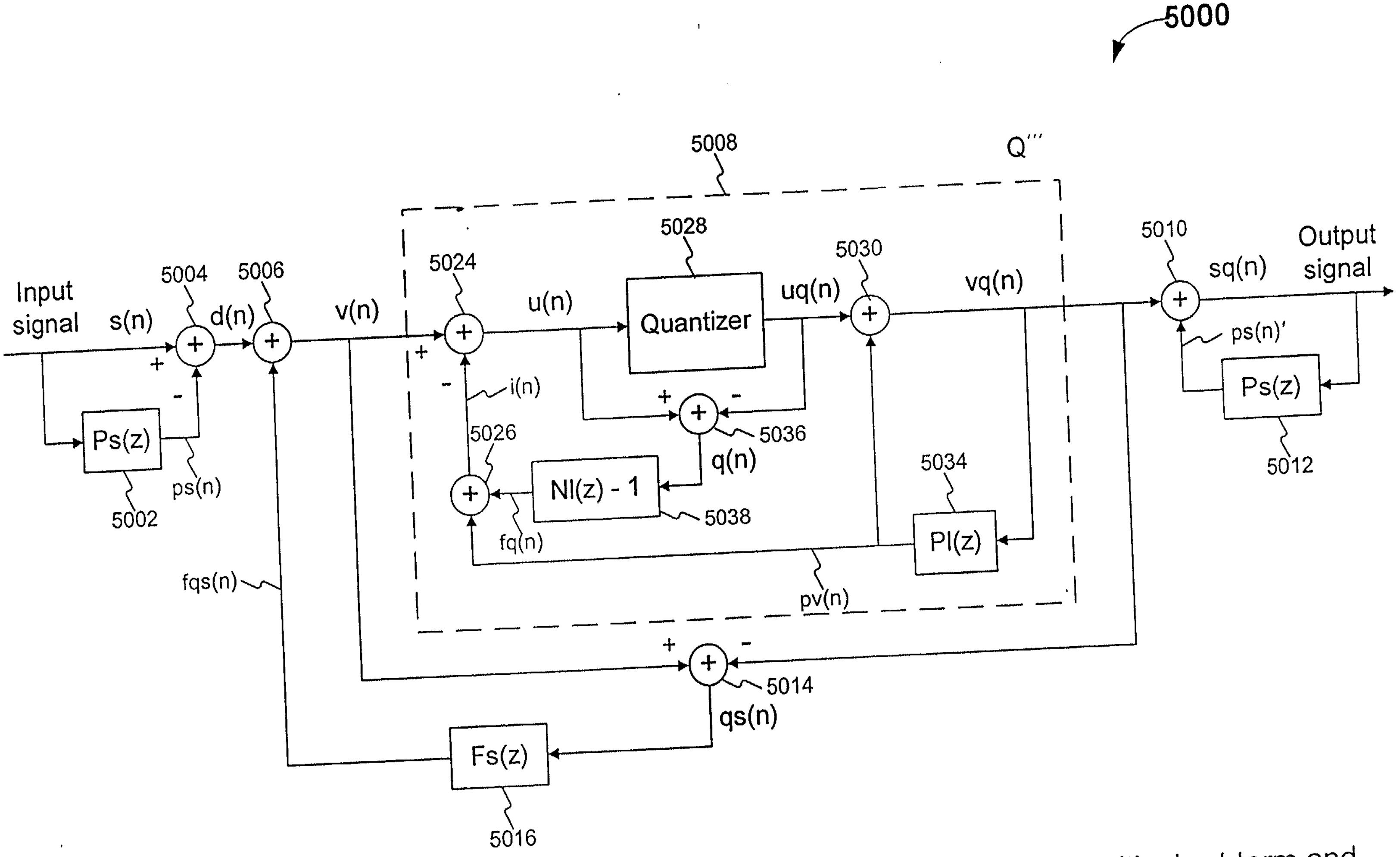


Figure 5 An alternative nested two-stage Noise Feedback Coding structure with short-term and long-term prediction and short-term and long-term noise spectral shaping

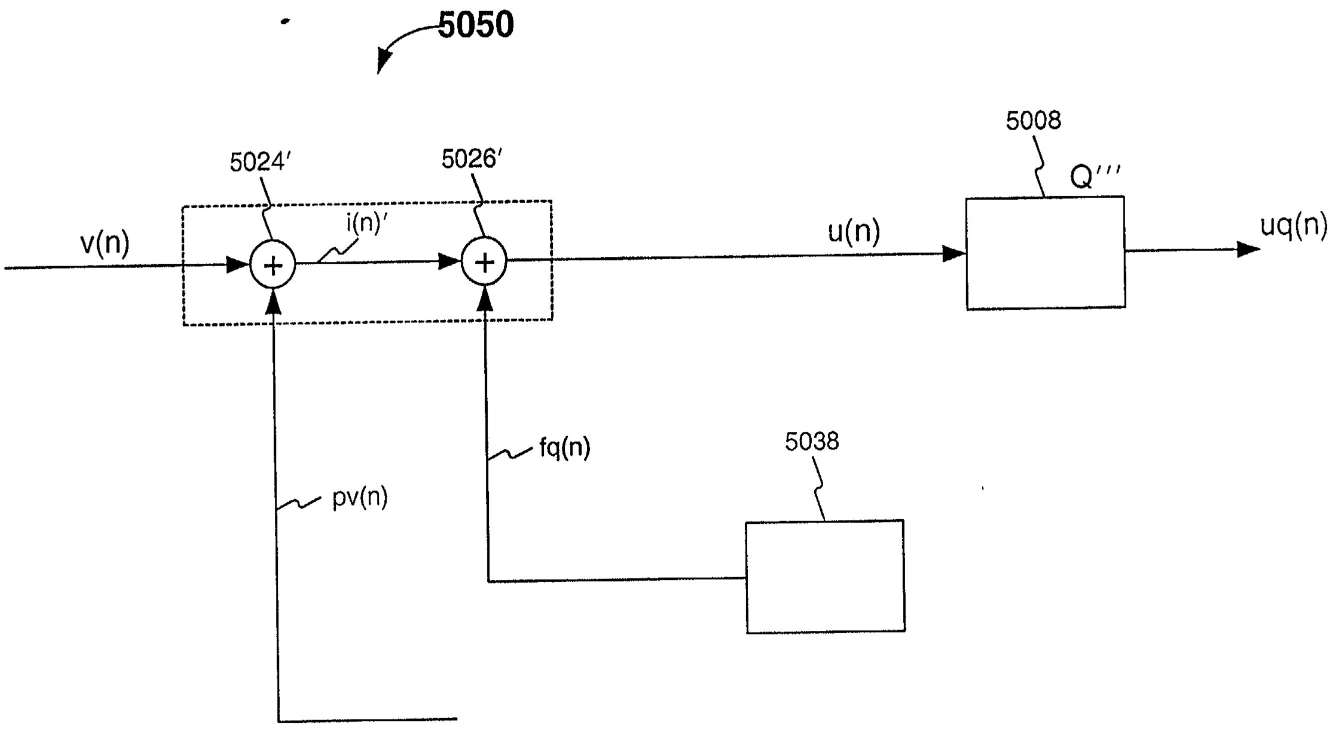


FIG. 5A

0003-56.vsd/8

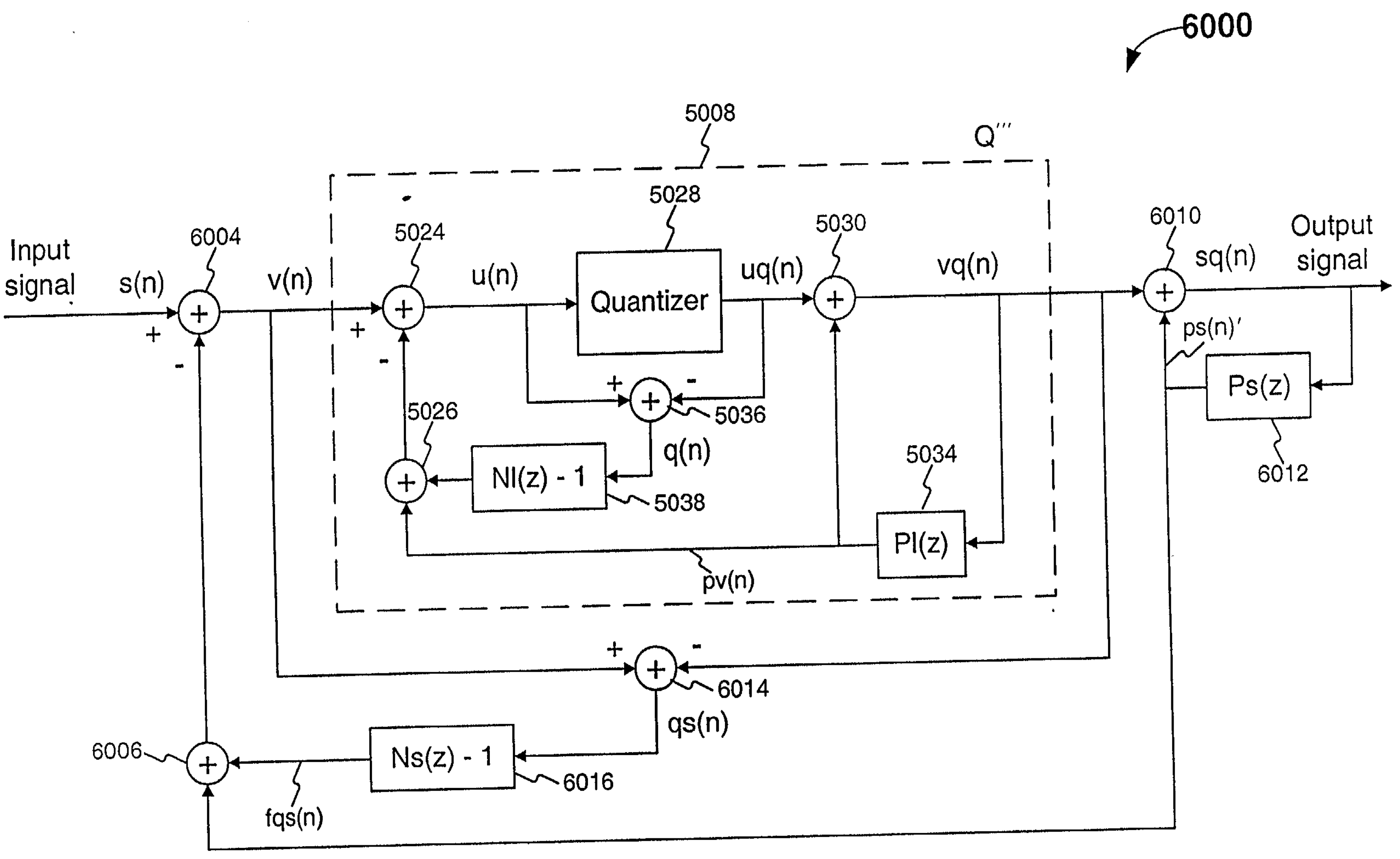


Figure 6 Another alternative nested two-stage Noise Feedback Coding structure with short-term and long-term prediction and short-term and long-term noise spectral shaping

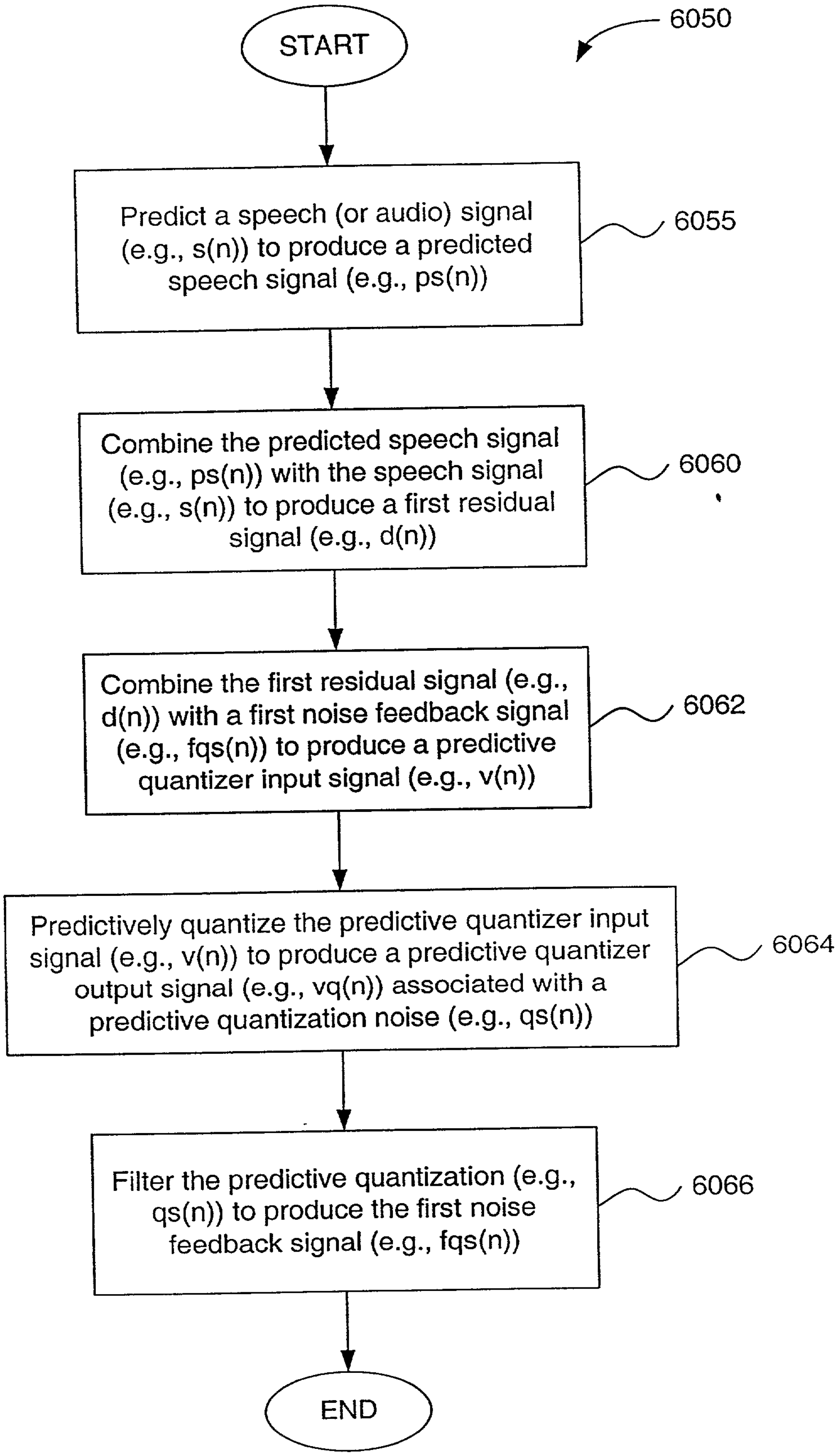

6050
START
Predict a speech (or audio) signal (e.g., s(n)) to produce a predicted speech signal (e.g., ps(n))
6055
Combine the predicted speech signal (e.g., ps(n)) with the speech signal (e.g., s(n)) to produce a first residual signal (e.g., d(n))
6060
Combine the first residual signal (e.g., d(n)) with a first noise feedback signal (e.g., fqs(n)) to produce a predictive quantizer input signal (e.g., v(n))
6062
Predictively quantize the predictive quantizer input signal (e.g., v(n)) to produce a predictive quantizer output signal (e.g., vq(n)) associated with a predictive quantization noise (e.g., qs(n))
6064
Filter the predictive quantization (e.g., qs(n)) to produce the first noise feedback signal (e.g., fqs(n))
6066
END

FIG. 6A

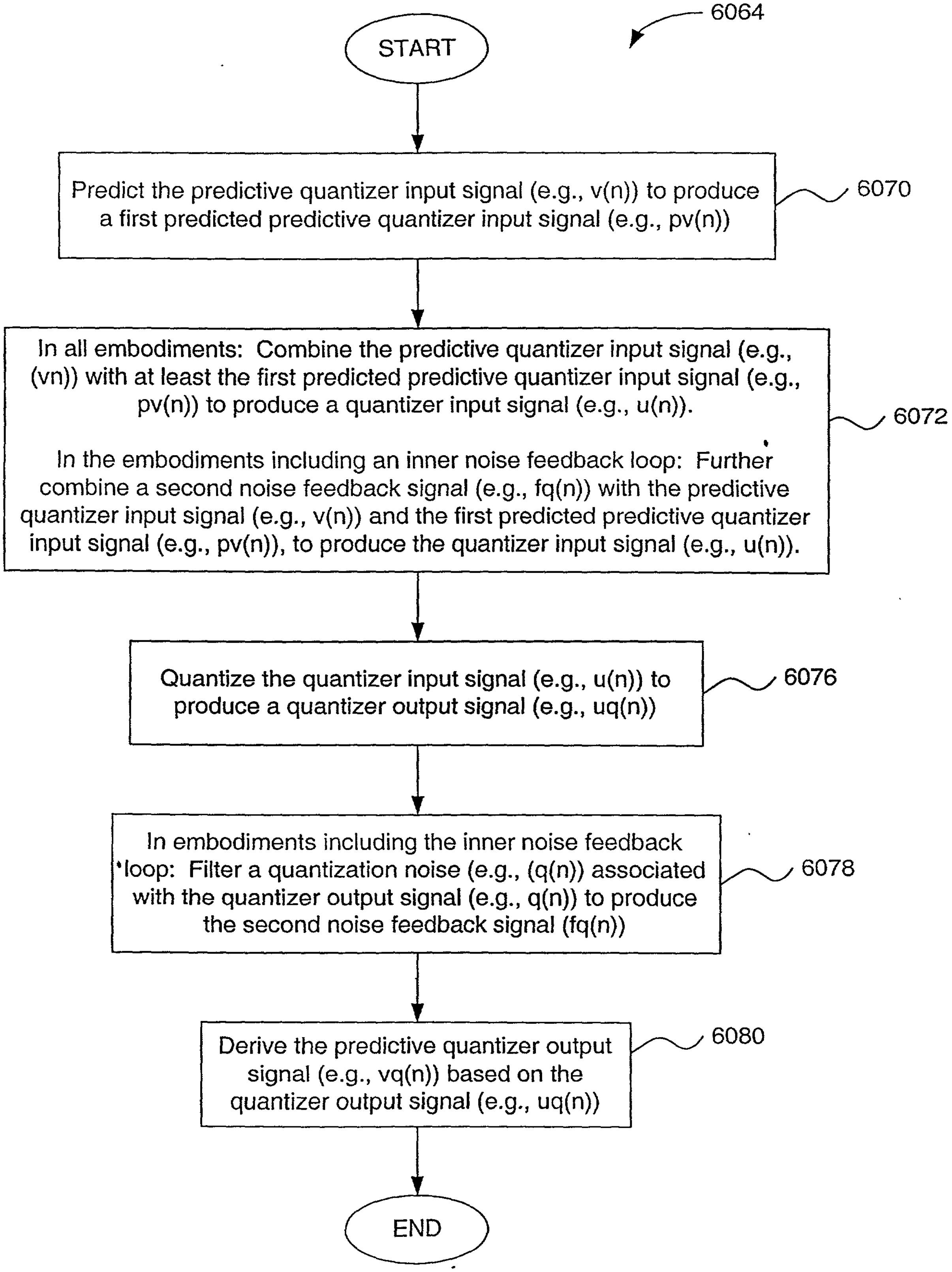

6064
START
Predict the predictive quantizer input signal (e.g., v(n)) to produce a first predicted predictive quantizer input signal (e.g., pv(n))
6070
In all embodiments: Combine the predictive quantizer input signal (e.g., (vn)) with at least the first predicted predictive quantizer input signal (e.g., pv(n)) to produce a quantizer input signal (e.g., u(n)).
In the embodiments including an inner noise feedback loop: Further combine a second noise feedback signal (e.g., fq(n)) with the predictive quantizer input signal (e.g., v(n)) and the first predicted predictive quantizer input signal (e.g., pv(n)), to produce the quantizer input signal (e.g., u(n)).
6072
Quantize the quantizer input signal (e.g., u(n)) to produce a quantizer output signal (e.g., uq(n))
6076
In embodiments including the inner noise feedback loop: Filter a quantization noise (e.g., (q(n)) associated with the quantizer output signal (e.g., q(n)) to produce the second noise feedback signal (fq(n))
6078
Derive the predictive quantizer output signal (e.g., vq(n)) based on the quantizer output signal (e.g., uq(n))
6080
END

FIG. 6B

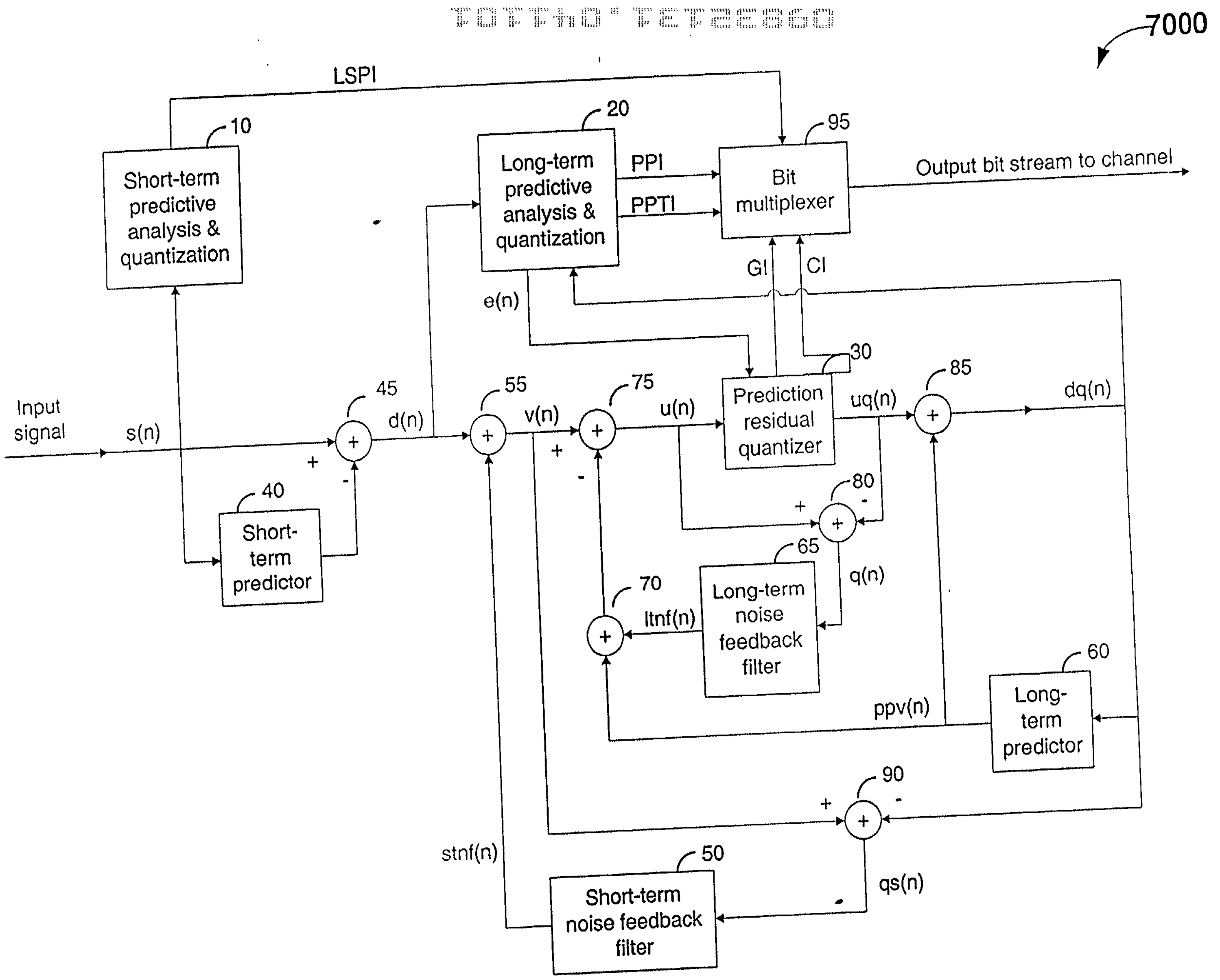


Figure 7 Encoder of a nested two-stage noise feedback codec (TSNFC)

0003-56.vsd/10

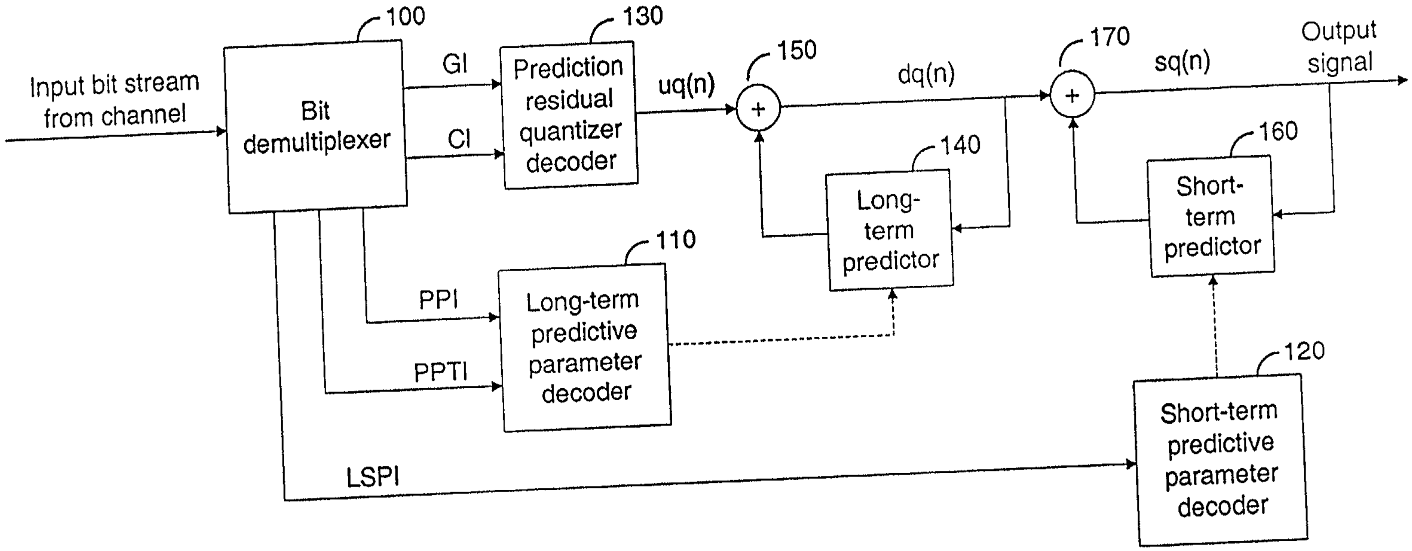


Figure 8 Decoder corresponding to the TSNFC encoder in Fig. 7

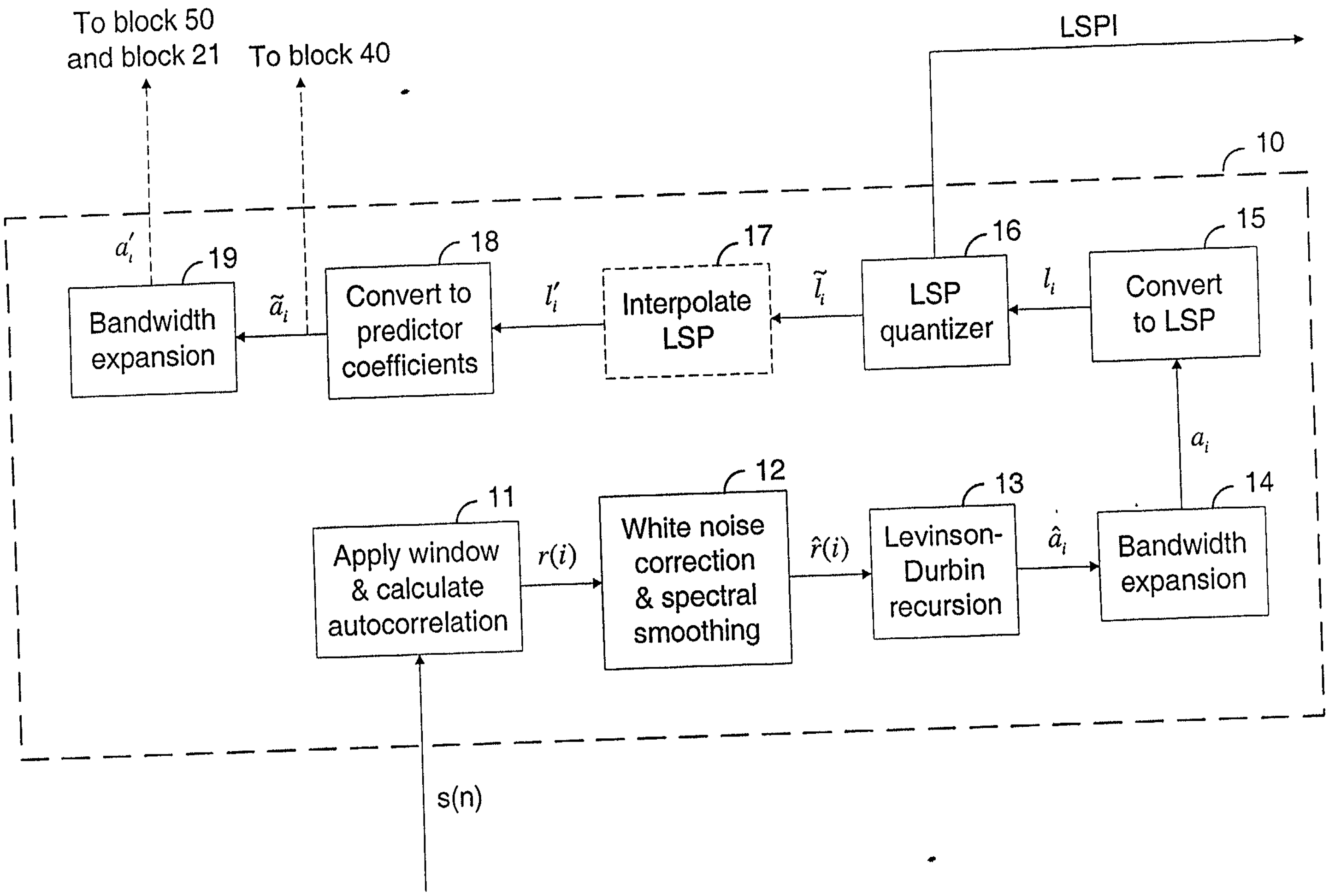


Figure 9 Short-term predictive analysis and quantization (block 10)

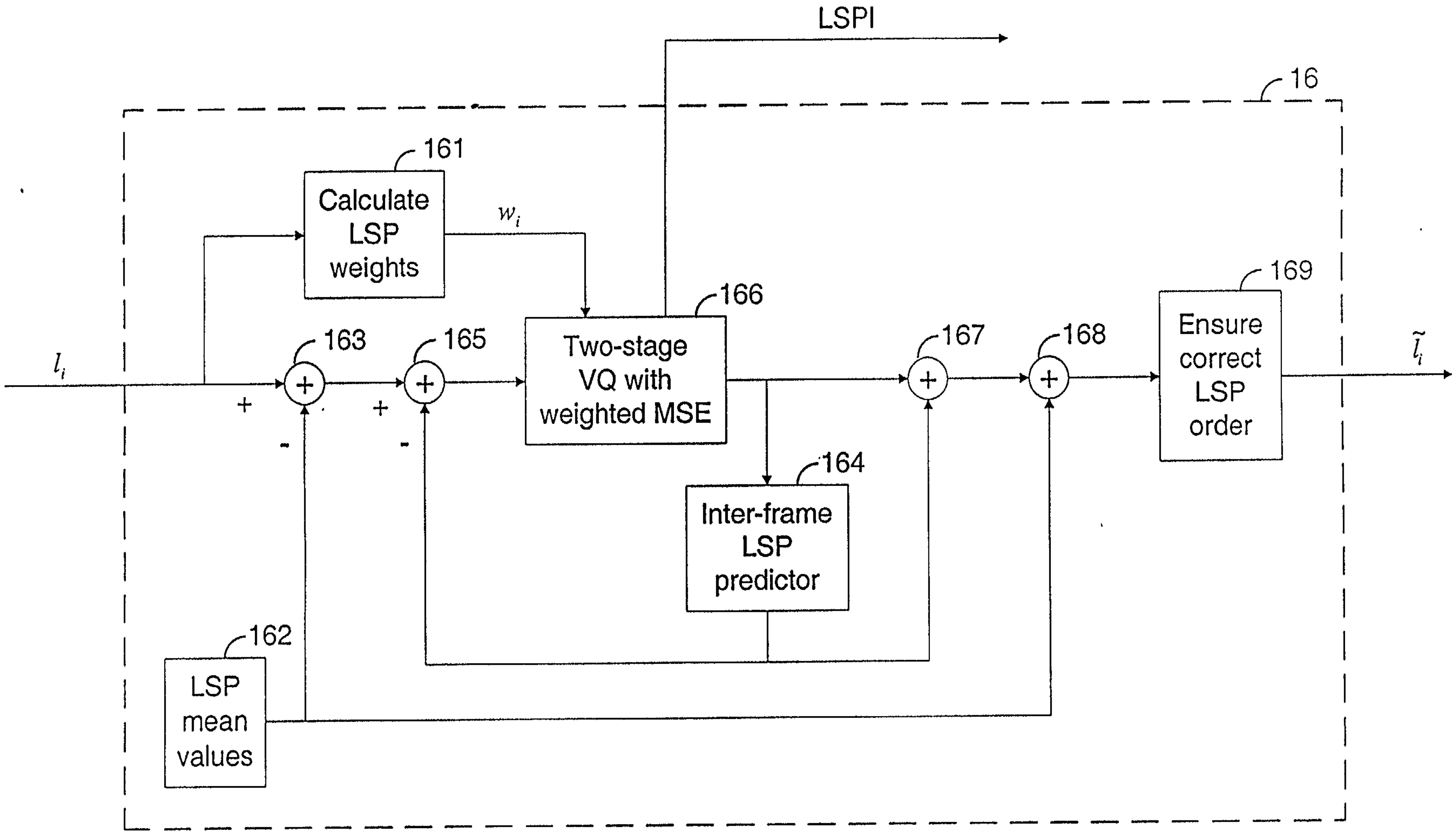


Figure 10 LSP quantizer (block 16)

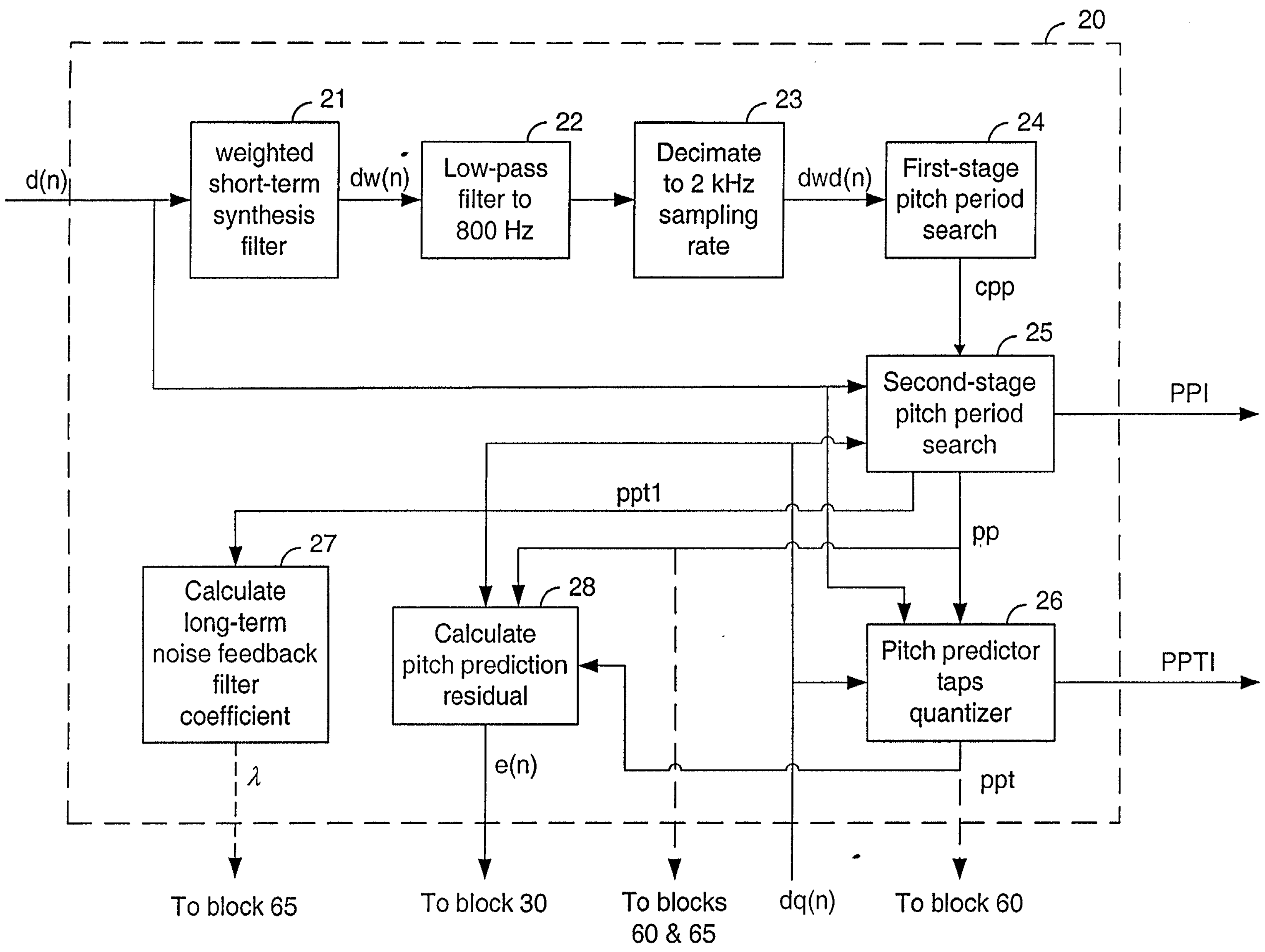


Figure 11 Long-term predictive analysis and quantization (block 20)

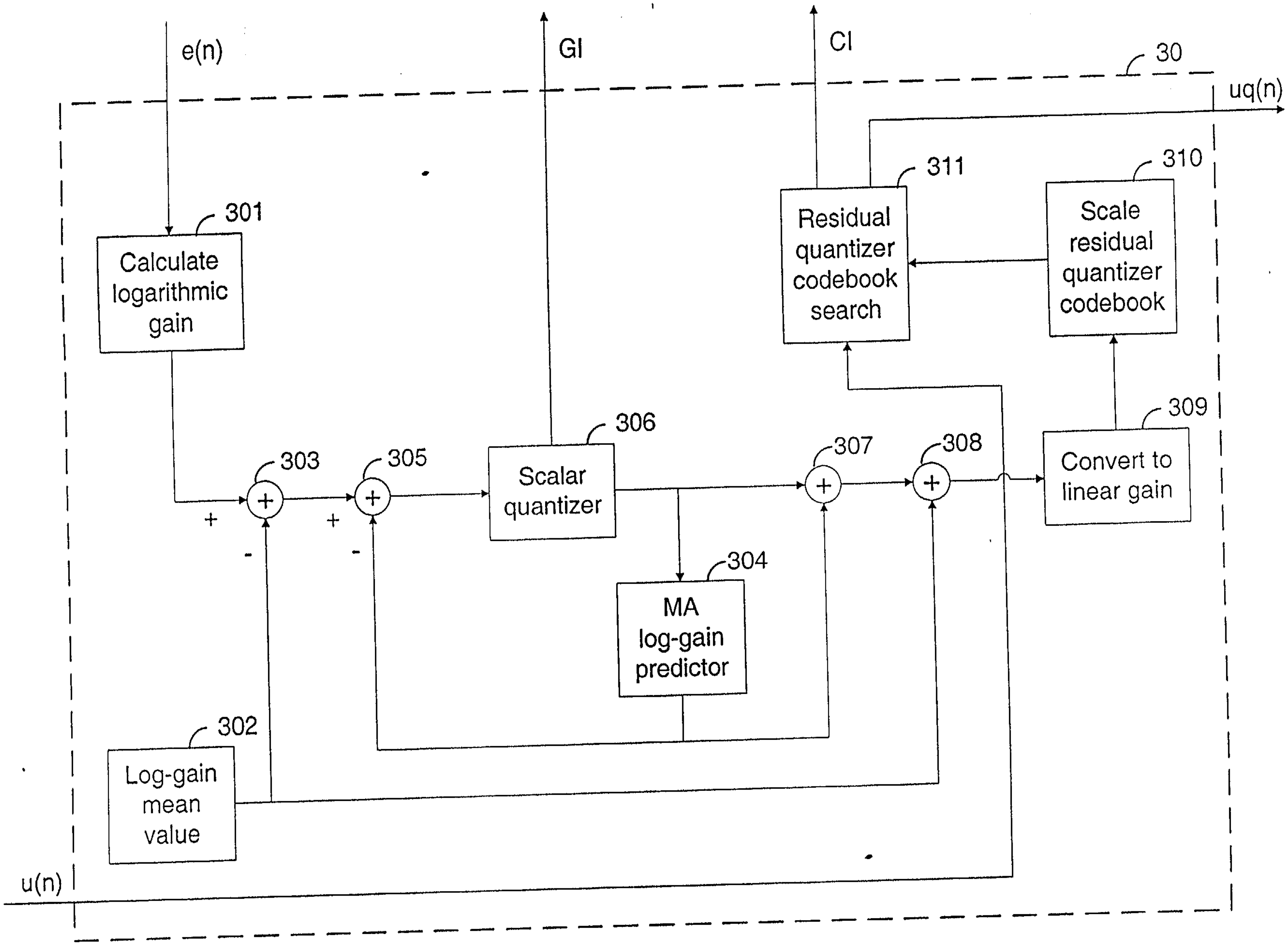


Figure 12 Prediction residual quantizer (block 30)

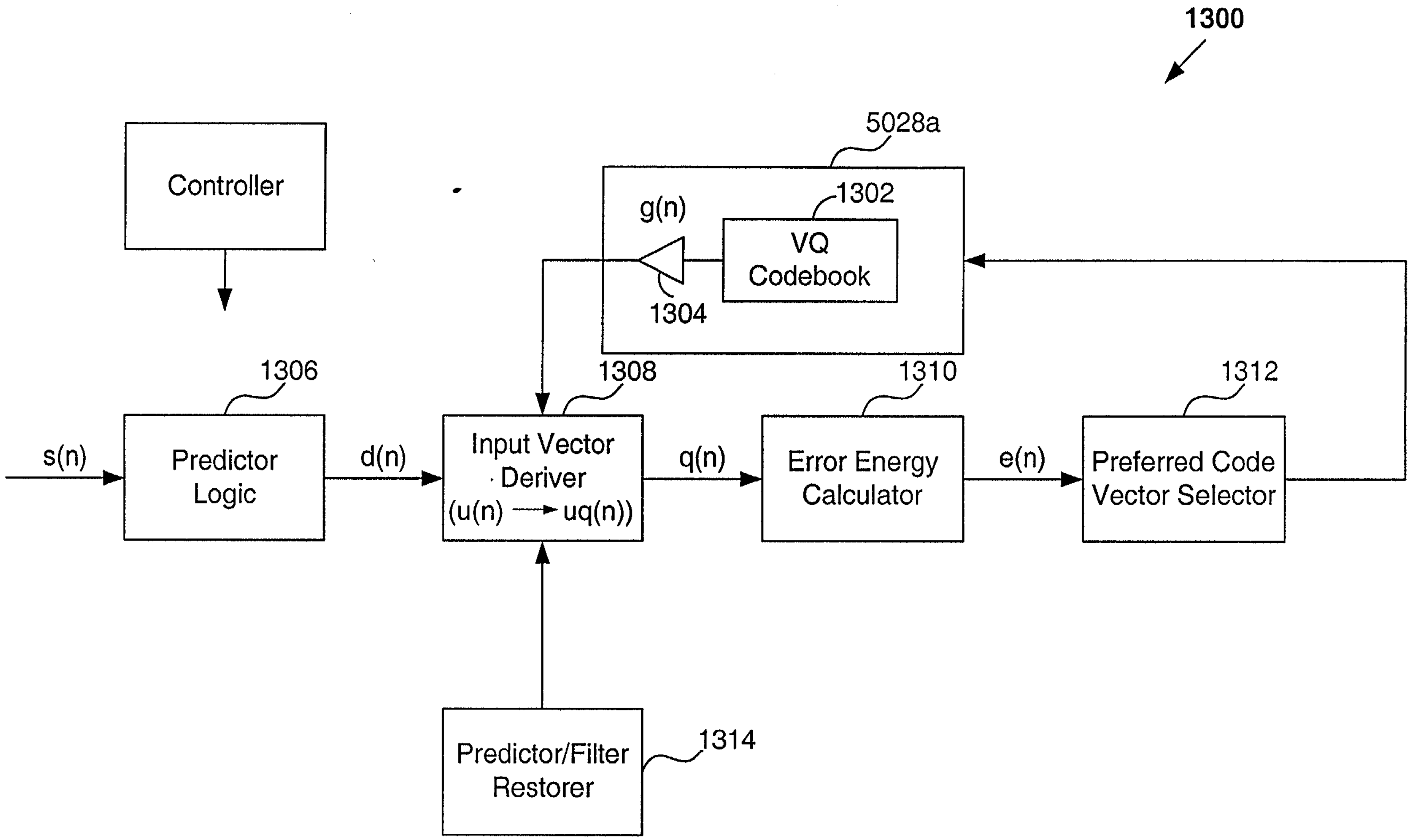


FIG. 13A

0101-41.vsd/1

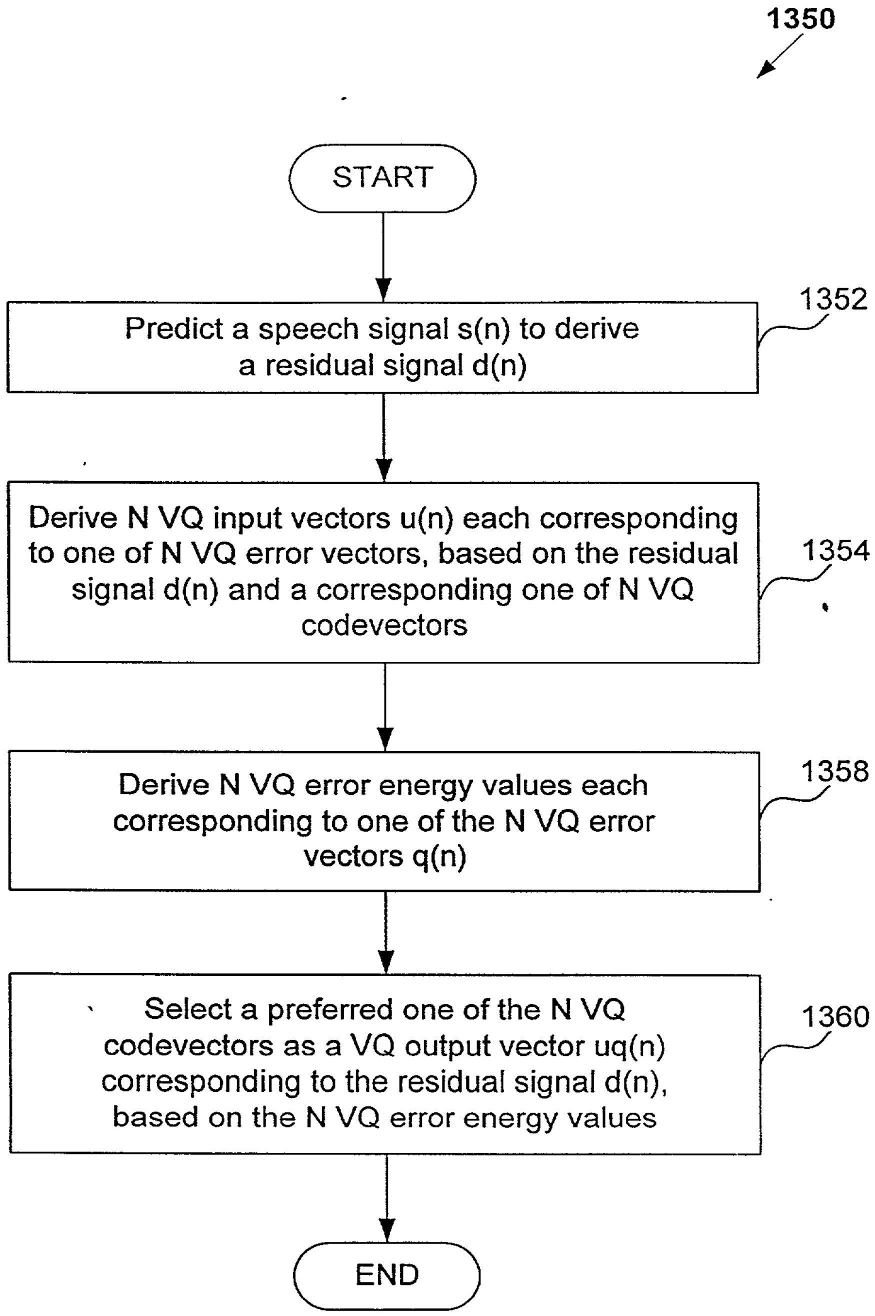
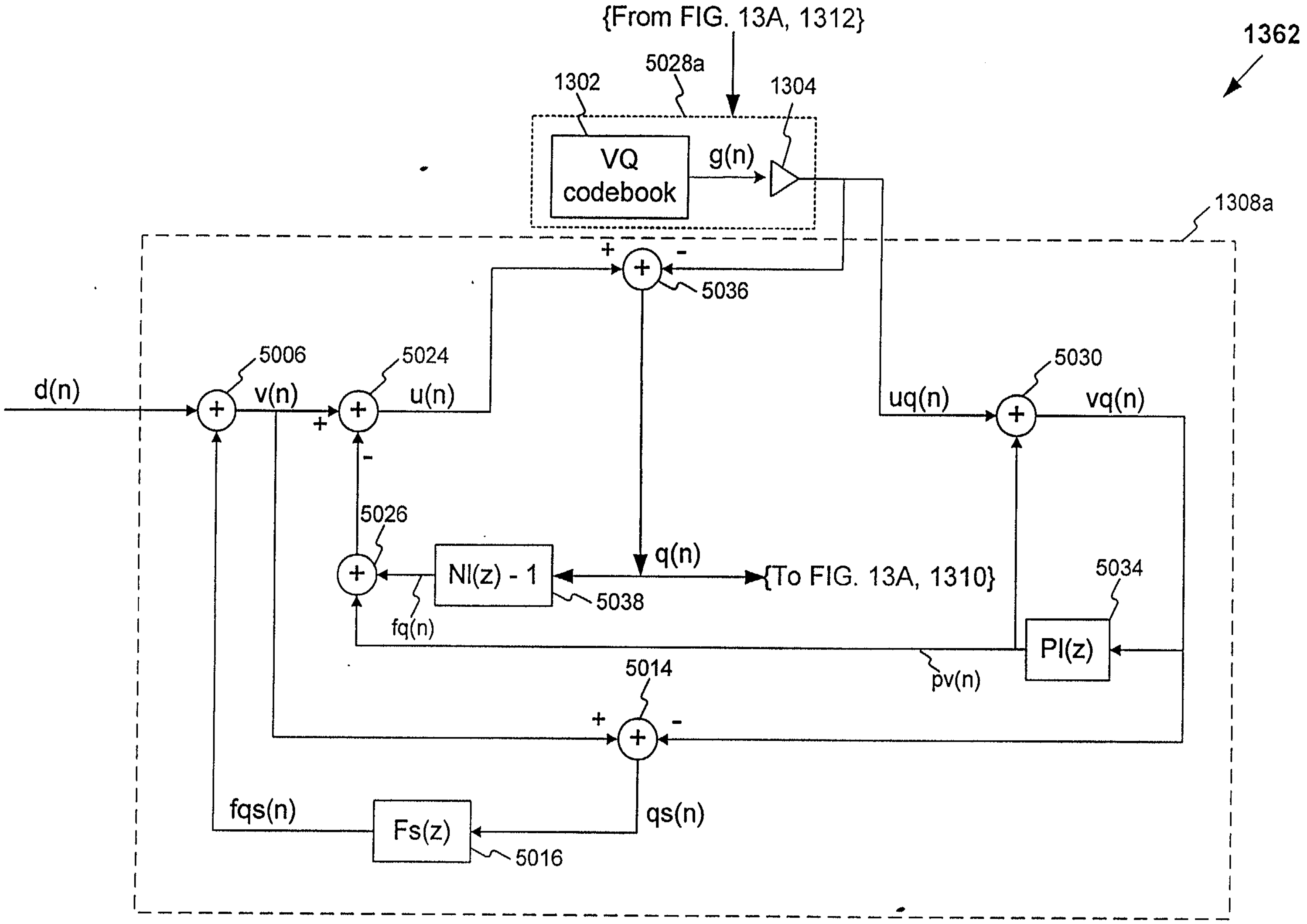

1350
START
Predict a speech signal s(n) to derive a residual signal d(n)
1352
Derive N VQ input vectors u(n) each corresponding to one of N VQ error vectors, based on the residual signal d(n) and a corresponding one of N VQ codevectors
1354
Derive N VQ error energy values each corresponding to one of the N VQ error vectors q(n)
1358
Select a preferred one of the N VQ codevectors as a VQ output vector uq(n) corresponding to the residual signal d(n), based on the N VQ error energy values
1360
END

FIG. 13B



The portion of the codec structure that is used in prediction residual VQ codebook search of the two-stage noise feedback codec of Fig. 5.

FIG. 13C

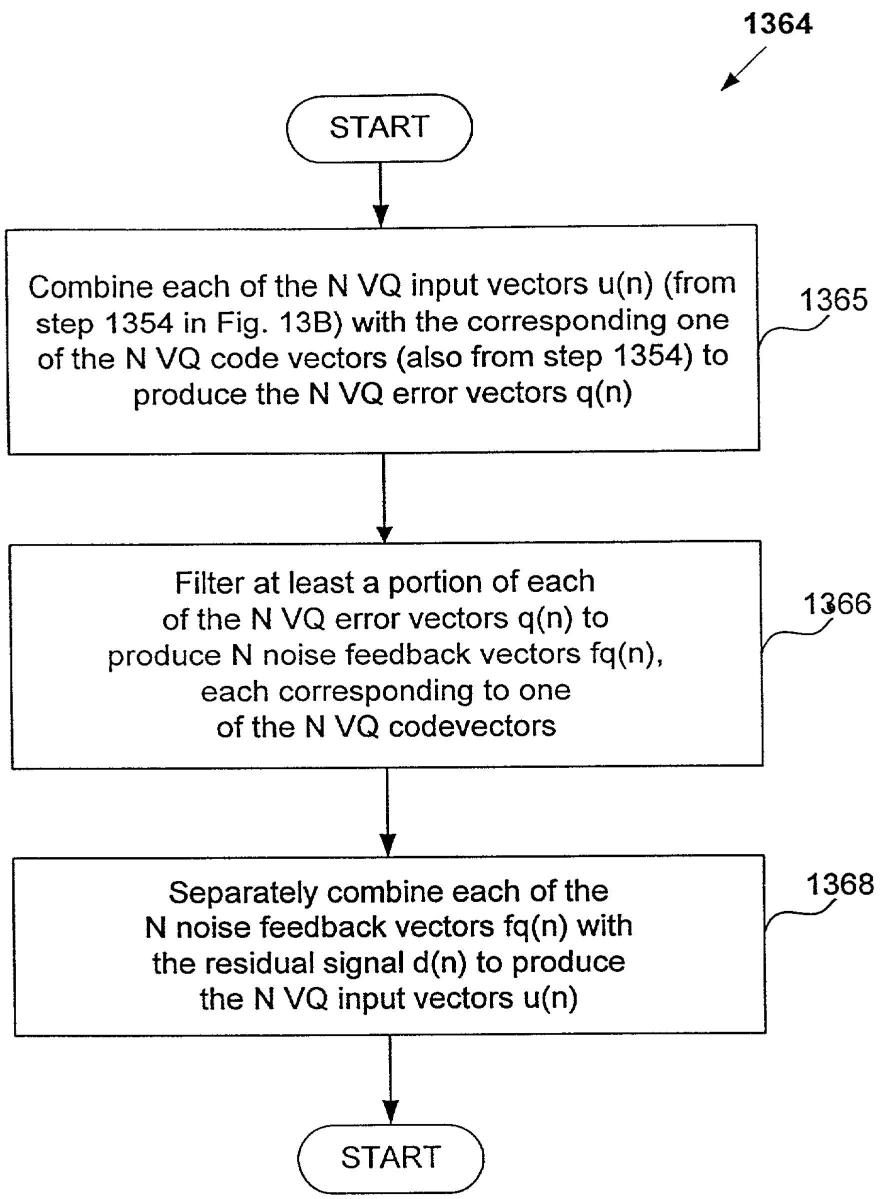

1364
START
Combine each of the N VQ input vectors u(n) (from step 1354 in Fig. 13B) with the corresponding one of the N VQ code vectors (also from step 1354) to produce the N VQ error vectors q(n)
1365
Filter at least a portion of each of the N VQ error vectors q(n) to produce N noise feedback vectors fq(n), each corresponding to one of the N VQ codevectors
1366
Separately combine each of the N noise feedback vectors fq(n) with the residual signal d(n) to produce the N VQ input vectors u(n)
1368
START

FIG. 13D

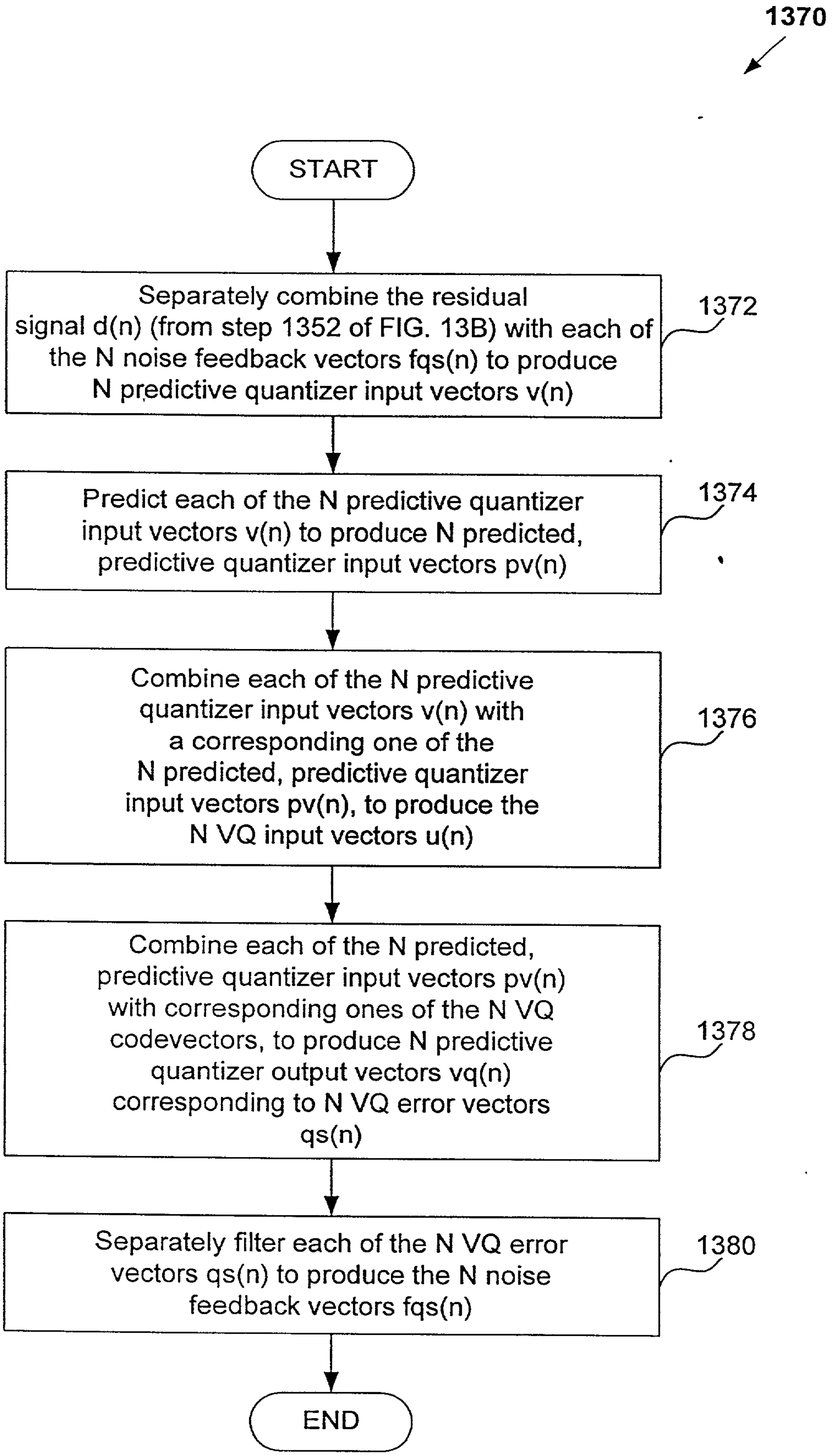

1370
START
Separately combine the residual signal d(n) (from step 1352 of FIG. 13B) with each of the N noise feedback vectors fqs(n) to produce N predictive quantizer input vectors v(n)
1372
Predict each of the N predictive quantizer input vectors v(n) to produce N predicted, predictive quantizer input vectors pv(n)
1374
Combine each of the N predictive quantizer input vectors v(n) with a corresponding one of the N predicted, predictive quantizer input vectors pv(n), to produce the N VQ input vectors u(n)
1376
Combine each of the N predicted, predictive quantizer input vectors pv(n) with corresponding ones of the N VQ codevectors, to produce N predictive quantizer output vectors vq(n) corresponding to N VQ error vectors qs(n)
1378
Separately filter each of the N VQ error vectors qs(n) to produce the N noise feedback vectors fqs(n)
1380
END

FIG. 13E

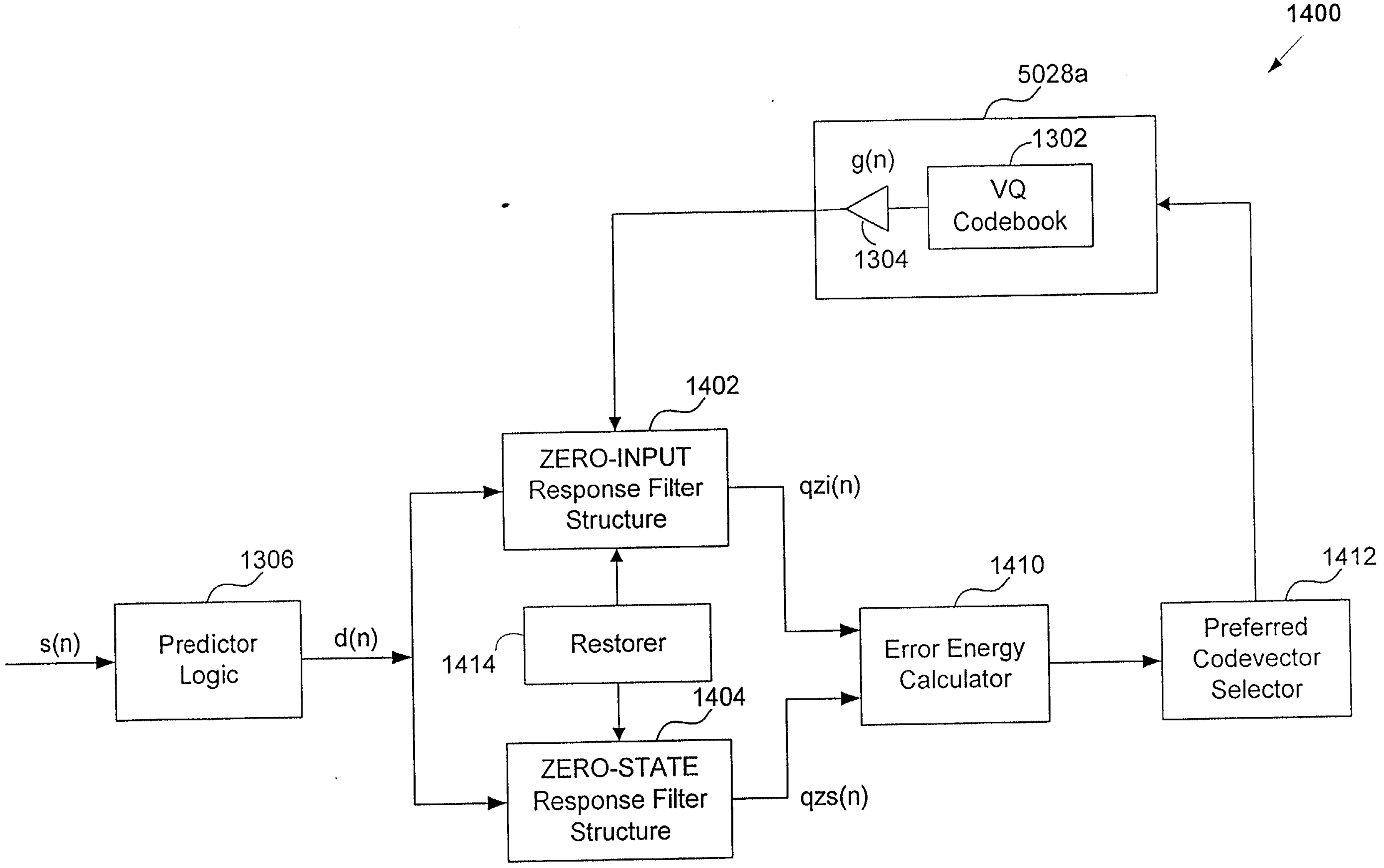

1400
5028a
1302
g(n)
VQ
Codebook
1304
1402
ZERO-INPUT
Response Filter
Structure
qzi(n)
1306
Predictor
Logic
s(n)
d(n)
1414
Restorer
1404
ZERO-STATE
Response Filter
Structure
qzs(n)
1410
Error Energy
Calculator
1412
Preferred
Codevector
Selector

FIG. 14A

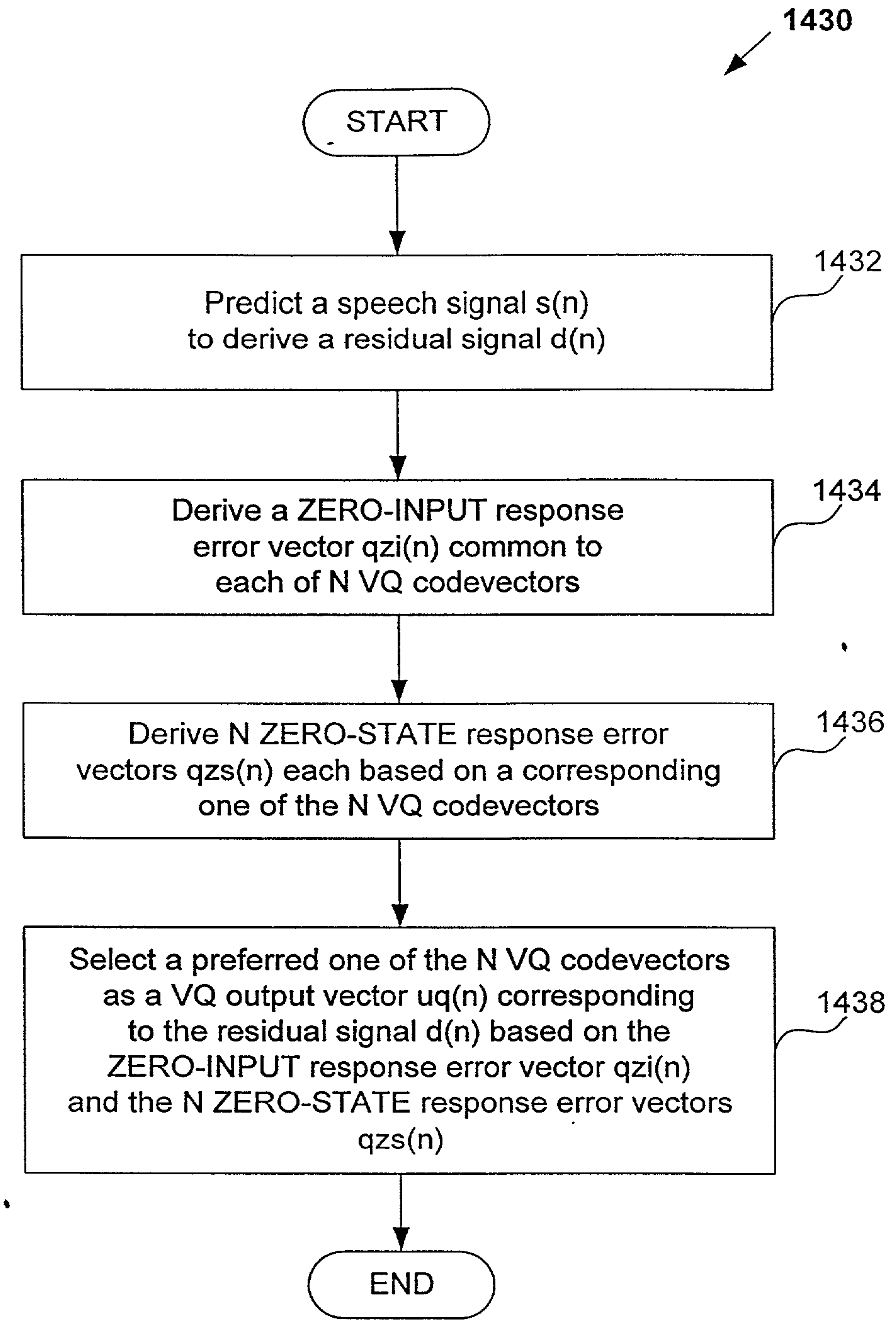
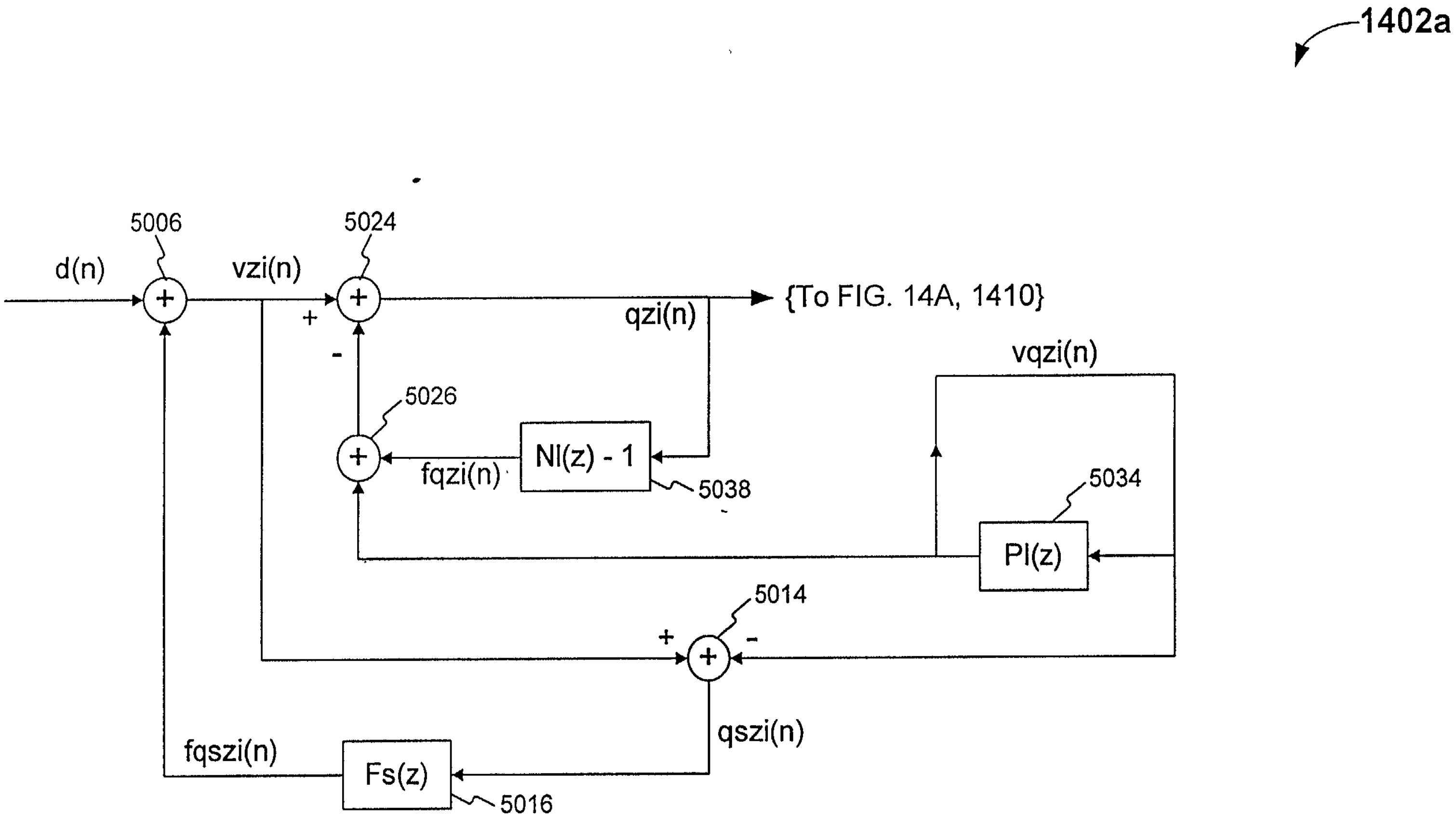

1430
START
Predict a speech signal s(n) to derive a residual signal d(n)
1432
Derive a ZERO-INPUT response error vector qzi(n) common to each of N VQ codevectors
1434
Derive N ZERO-STATE response error vectors qzs(n) each based on a corresponding one of the N VQ codevectors
1436
Select a preferred one of the N VQ codevectors as a VQ output vector uq(n) corresponding to the residual signal d(n) based on the ZERO-INPUT response error vector qzi(n) and the N ZERO-STATE response error vectors qzs(n)
1438
END

FIG. 14B



Filter structure during the calculation of the zero-input response of q(n) of Fig. 13C.

FIG. 14C

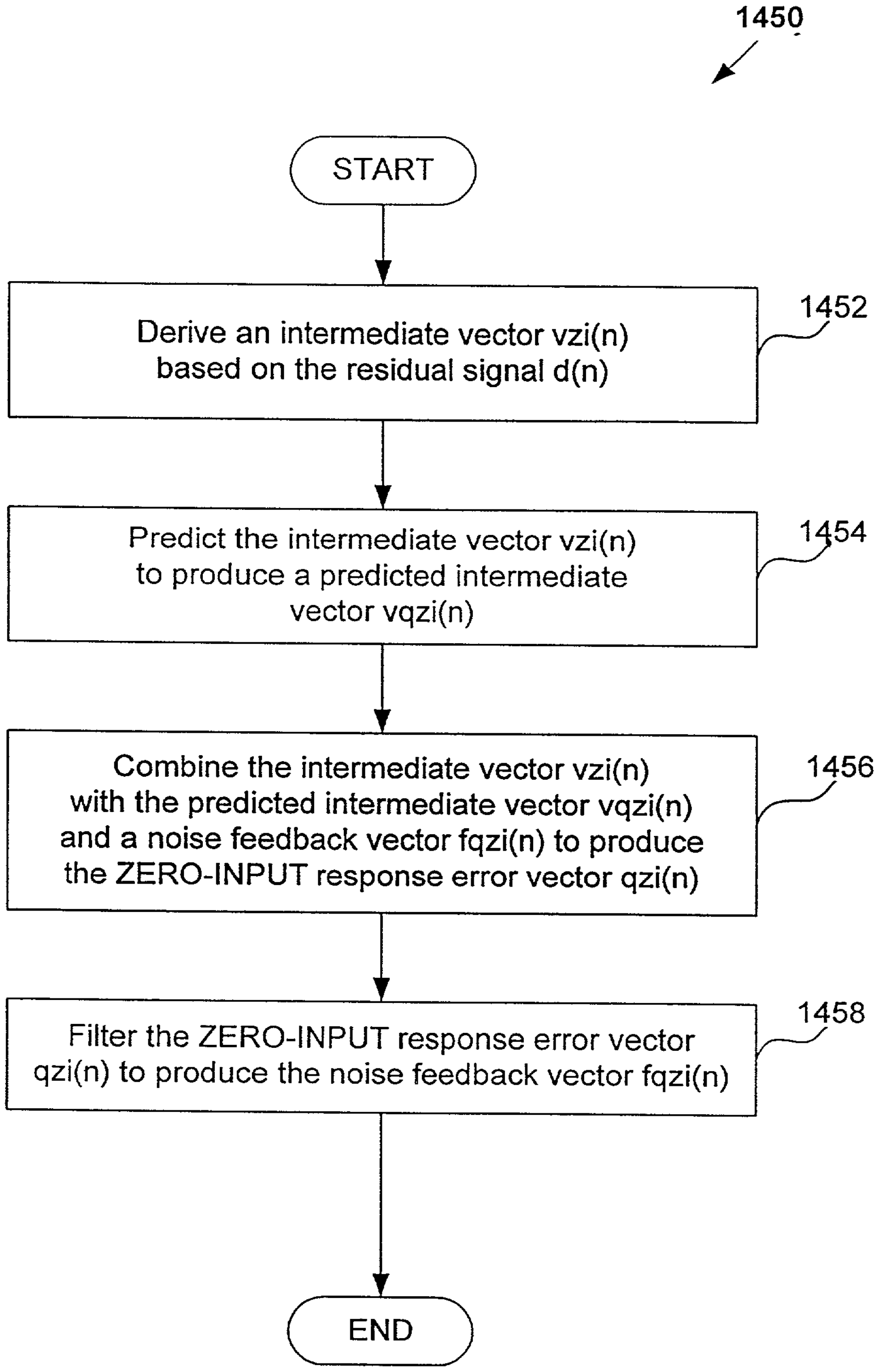

1450
START
Derive an intermediate vector vzi(n) based on the residual signal d(n)
1452
Predict the intermediate vector vzi(n) to produce a predicted intermediate vector vqzi(n)
1454
Combine the intermediate vector vzi(n) with the predicted intermediate vector vqzi(n) and a noise feedback vector fqzi(n) to produce the ZERO-INPUT response error vector qzi(n)
1456
Filter the ZERO-INPUT response error vector qzi(n) to produce the noise feedback vector fqzi(n)
1458
END

FIG. 14D

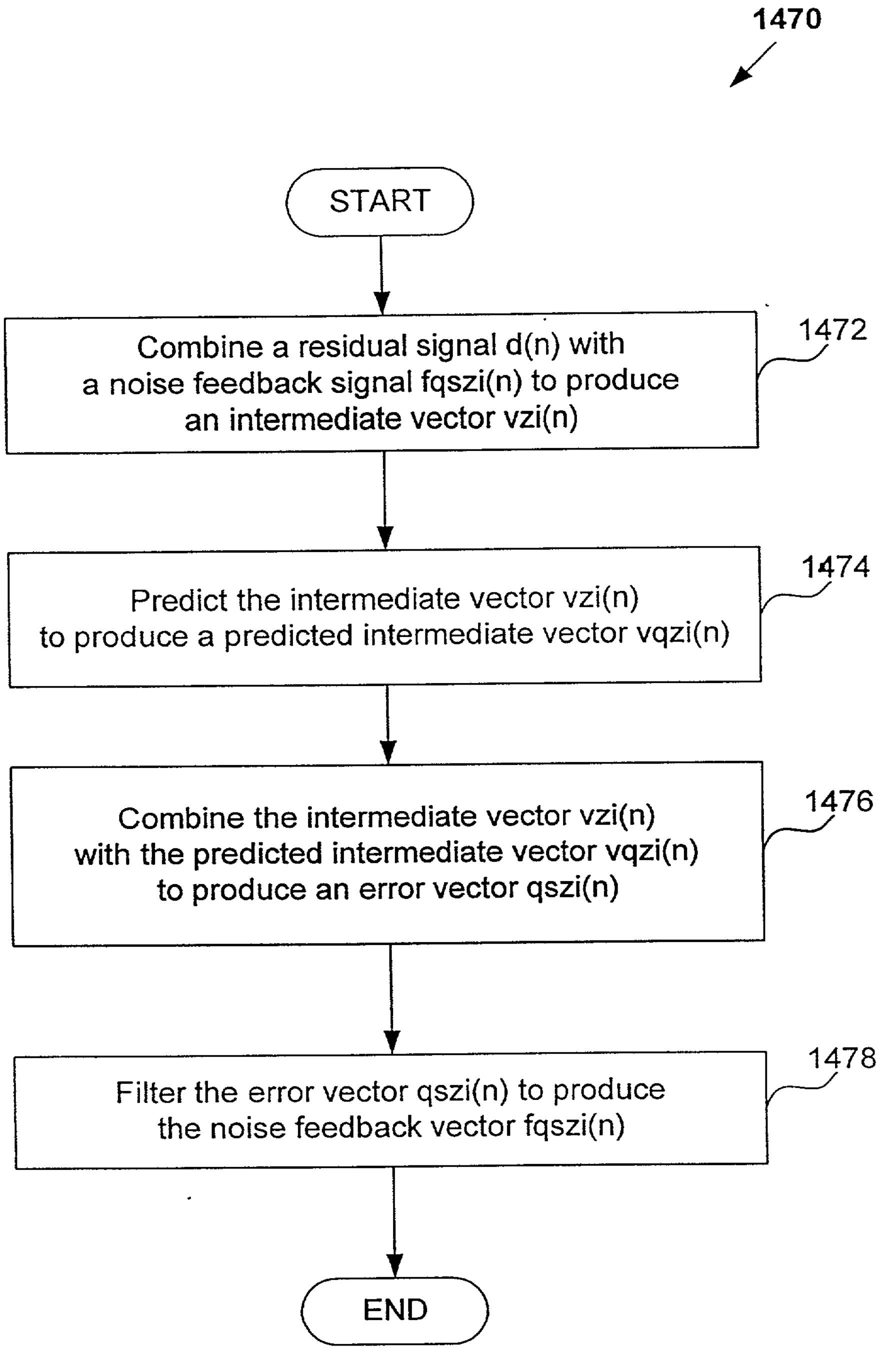
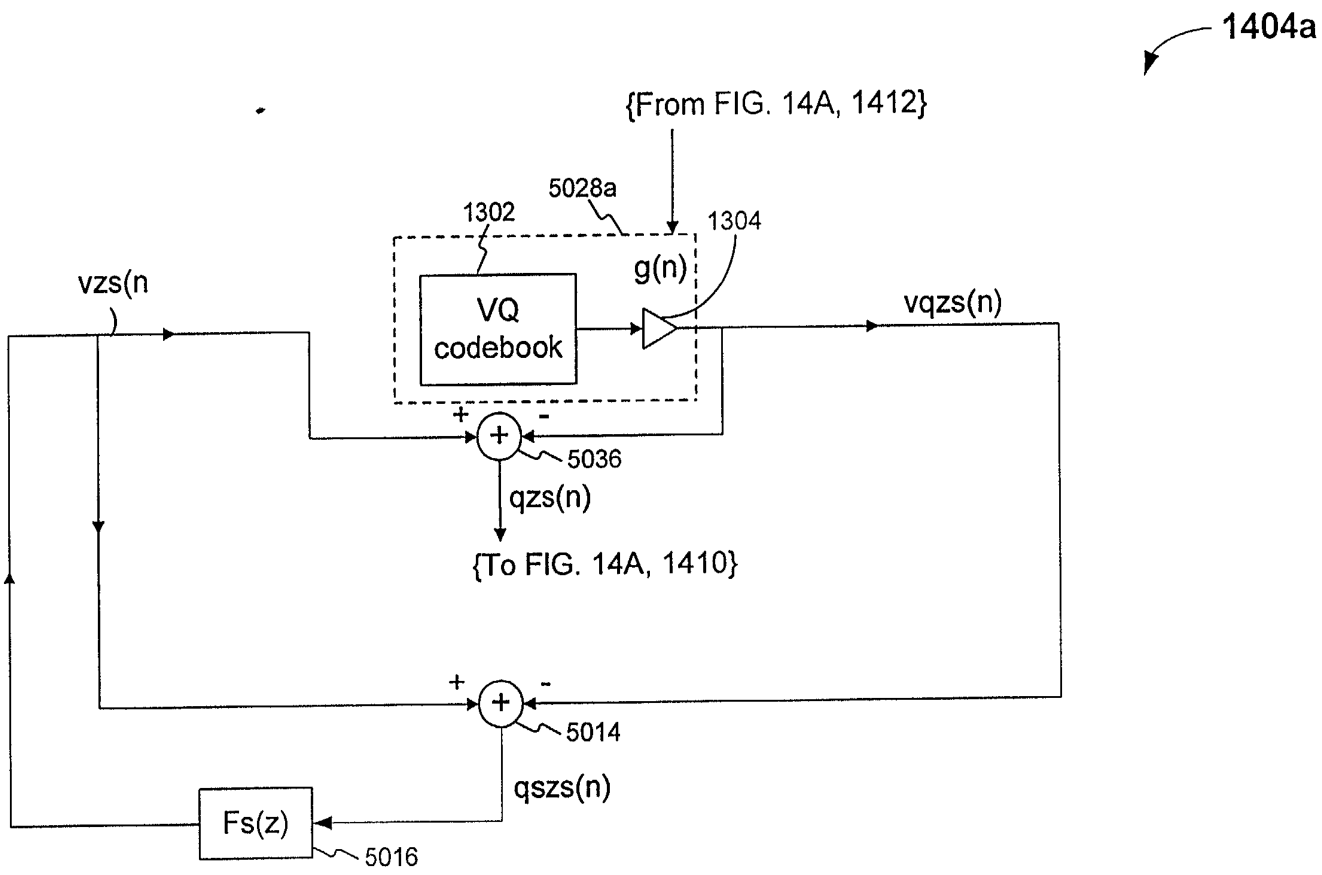

1470
START
Combine a residual signal d(n) with a noise feedback signal fqszi(n) to produce an intermediate vector vzi(n)
1472
Predict the intermediate vector vzi(n) to produce a predicted intermediate vector vqzi(n)
1474
Combine the intermediate vector vzi(n) with the predicted intermediate vector vqzi(n) to produce an error vector qszi(n)
1476
Filter the error vector qszi(n) to produce the noise feedback vector fqszi(n)
1478
END

FIG. 14E



Filter structure during the calculation of the zero-state response of q(n) in Fig. 13C.

FIG. 15A

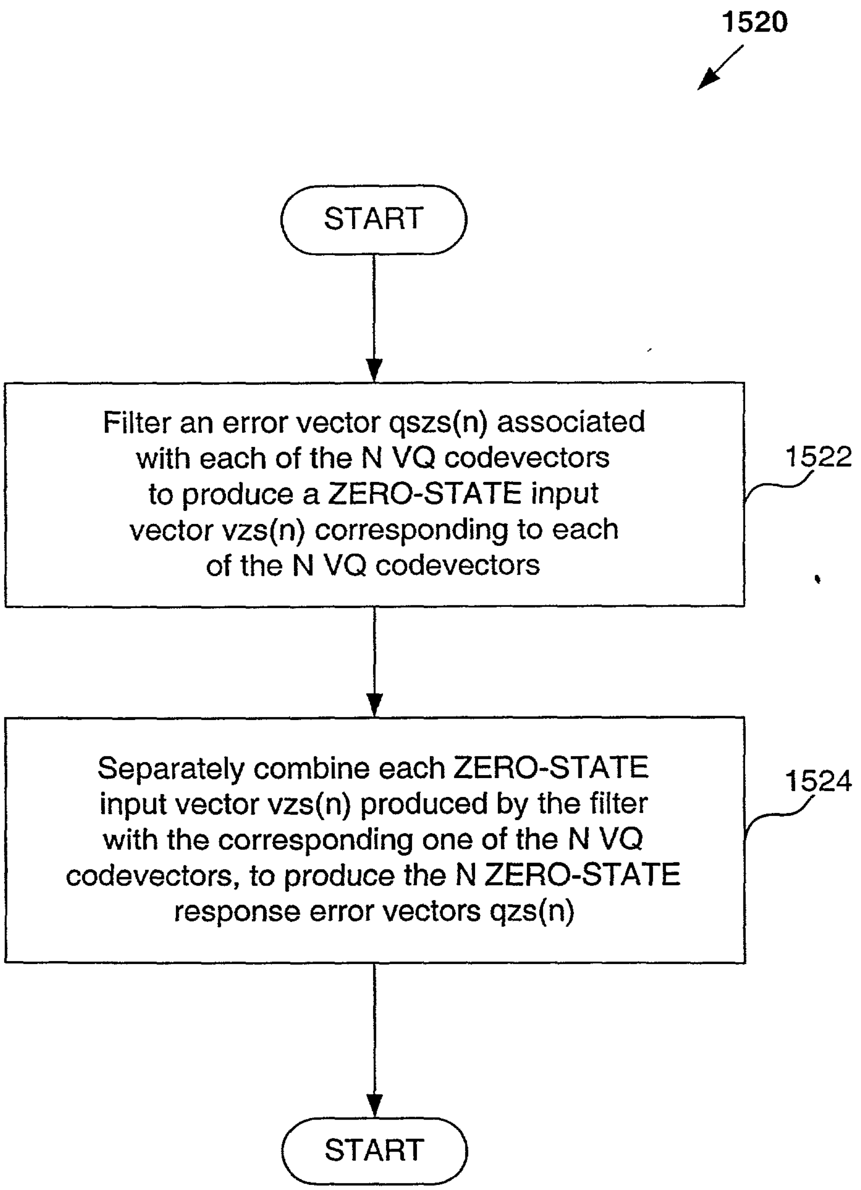
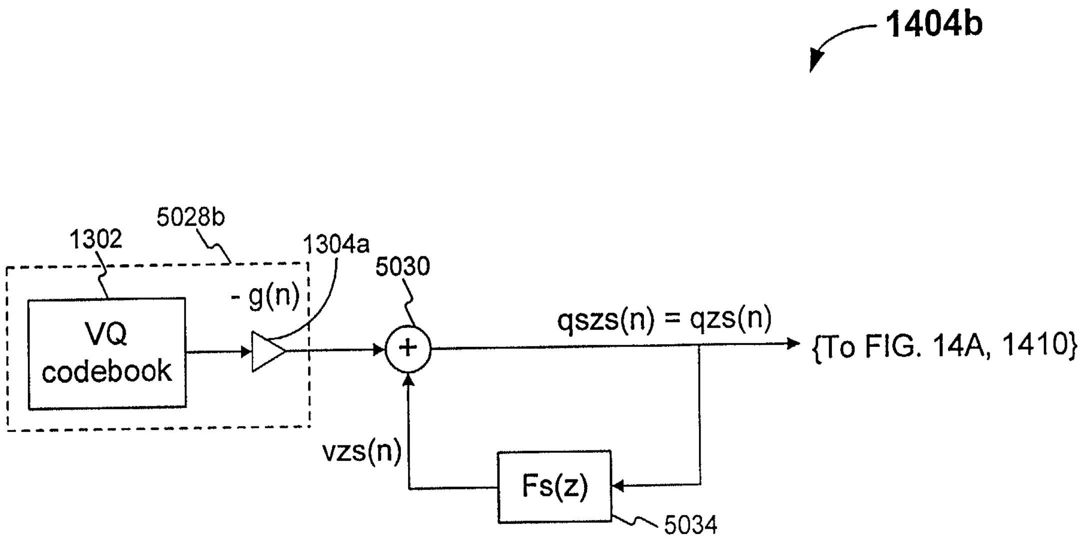

1520
START
Filter an error vector qszs(n) associated with each of the N VQ codevectors to produce a ZERO-STATE input vector vzs(n) corresponding to each of the N VQ codevectors
1522
Separately combine each ZERO-STATE input vector vzs(n) produced by the filter with the corresponding one of the N VQ codevectors, to produce the N ZERO-STATE response error vectors qzs(n)
1524
START

FIG. 15B



A filter structure equivalent to the structure in Fig. 15A.

FIG. 16A

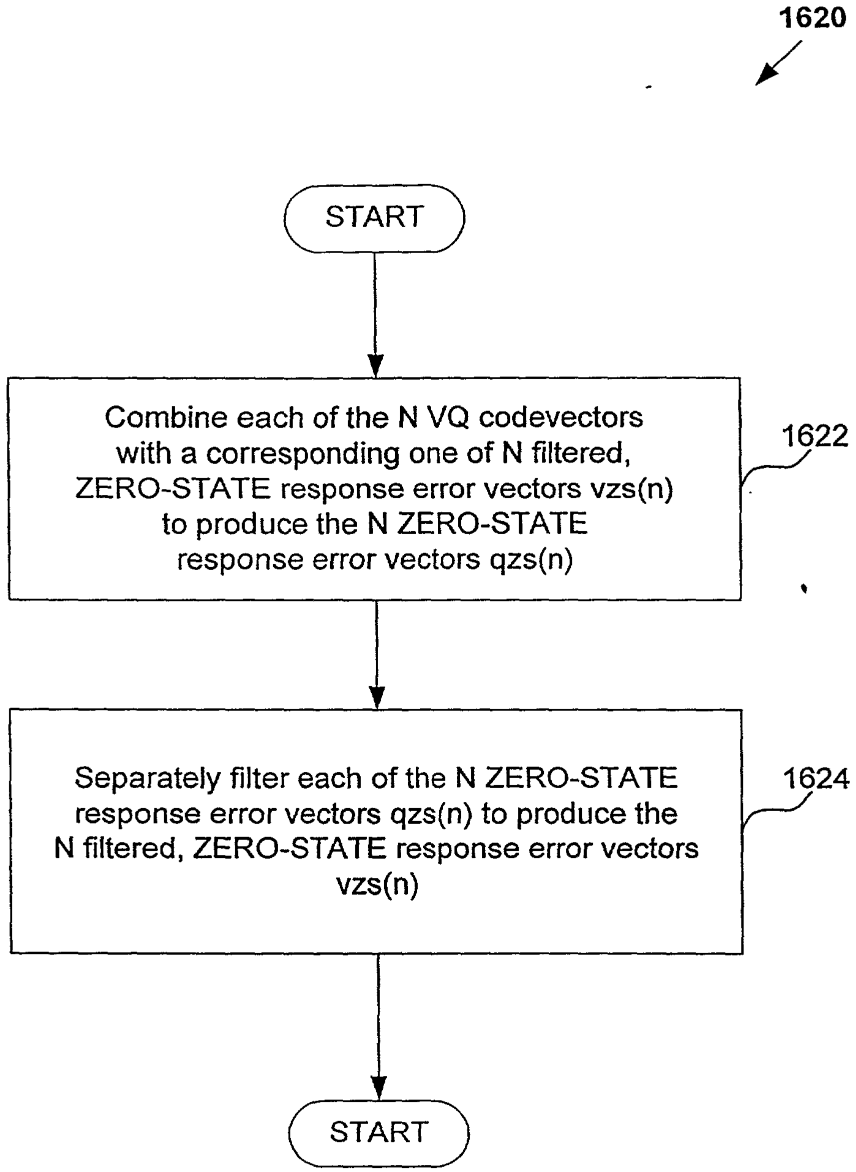

1620
START
Combine each of the N VQ codevectors with a corresponding one of N filtered, ZERO-STATE response error vectors vzs(n) to produce the N ZERO-STATE response error vectors qzs(n)
1622
Separately filter each of the N ZERO-STATE response error vectors qzs(n) to produce the N filtered, ZERO-STATE response error vectors vzs(n)
1624
START

FIG. 16B

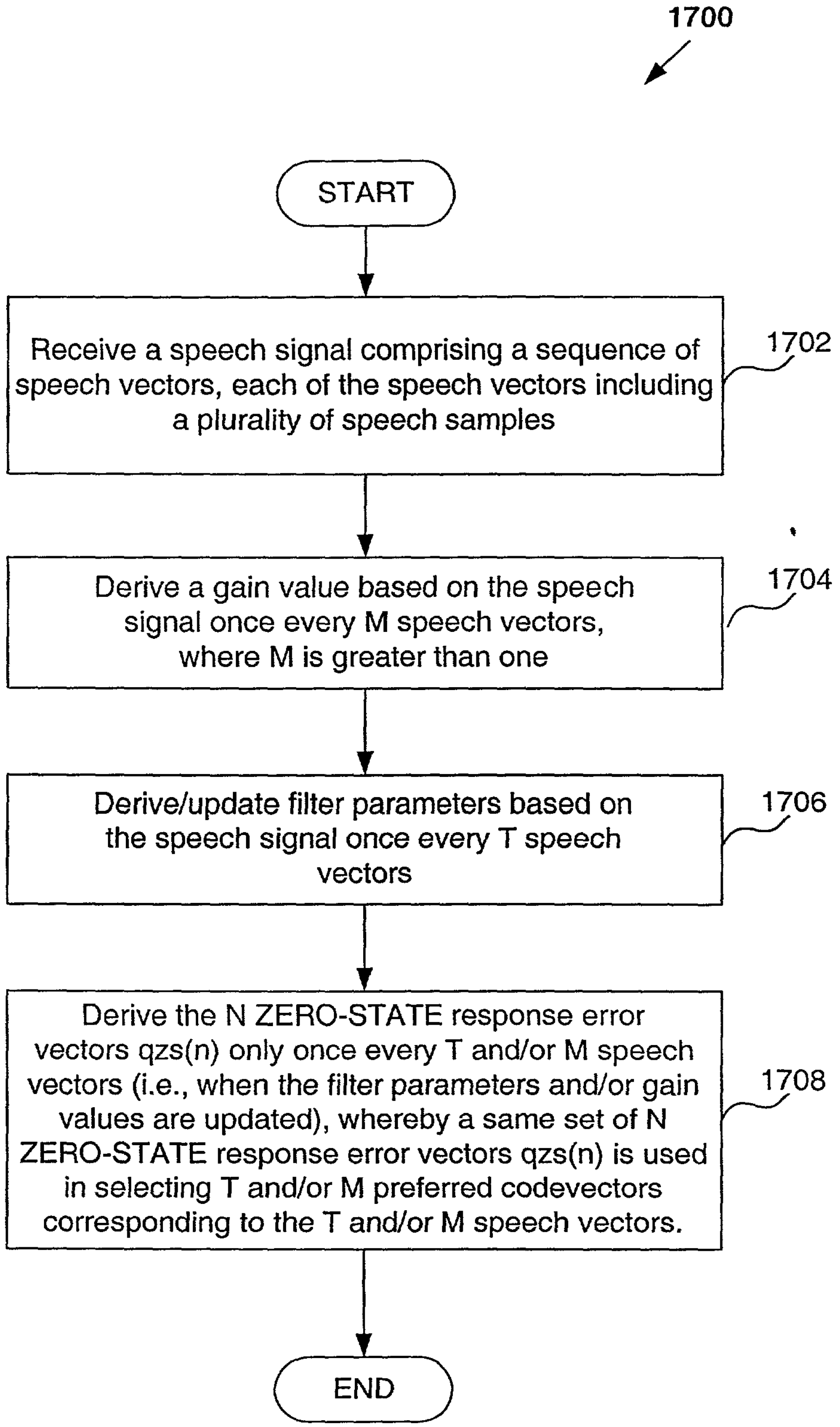

1700
START
Receive a speech signal comprising a sequence of speech vectors, each of the speech vectors including a plurality of speech samples
1702
Derive a gain value based on the speech signal once every M speech vectors, where M is greater than one
1704
Derive/update filter parameters based on the speech signal once every T speech vectors
1706
Derive the N ZERO-STATE response error vectors qzs(n) only once every T and/or M speech vectors (i.e., when the filter parameters and/or gain values are updated), whereby a same set of N ZERO-STATE response error vectors qzs(n) is used in selecting T and/or M preferred codevectors corresponding to the T and/or M speech vectors.
1708
END

FIG. 17

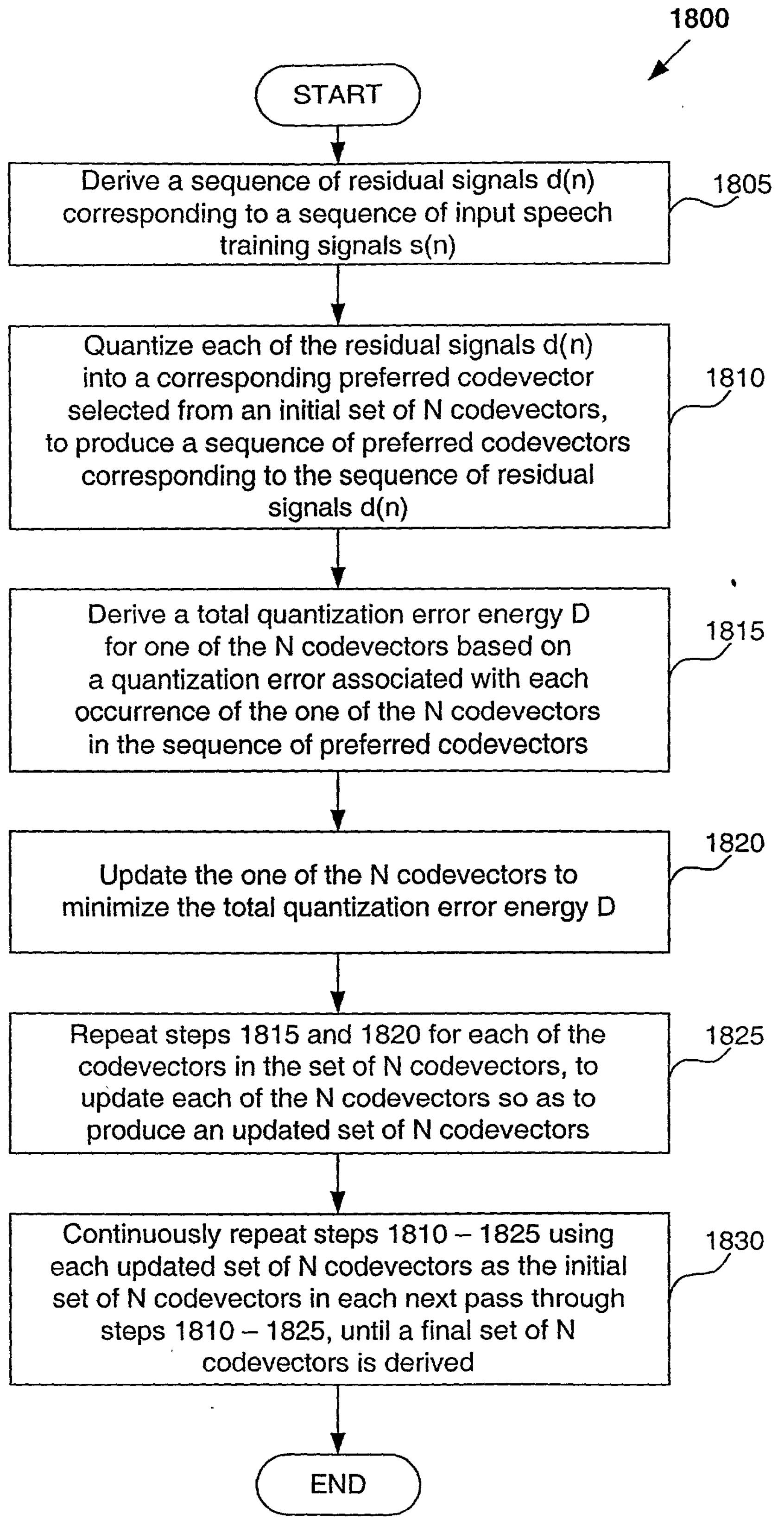

1800
START
Derive a sequence of residual signals d(n) corresponding to a sequence of input speech training signals s(n)
1805
Quantize each of the residual signals d(n) into a corresponding preferred codevector selected from an initial set of N codevectors, to produce a sequence of preferred codevectors corresponding to the sequence of residual signals d(n)
1810
Derive a total quantization error energy D for one of the N codevectors based on a quantization error associated with each occurrence of the one of the N codevectors in the sequence of preferred codevectors
1815
Update the one of the N codevectors to minimize the total quantization error energy D
1820
Repeat steps 1815 and 1820 for each of the codevectors in the set of N codevectors, to update each of the N codevectors so as to produce an updated set of N codevectors
1825
Continuously repeat steps 1810 – 1825 using each updated set of N codevectors as the initial set of N codevectors in each next pass through steps 1810 – 1825, until a final set of N codevectors is derived
1830
END

FIG. 18

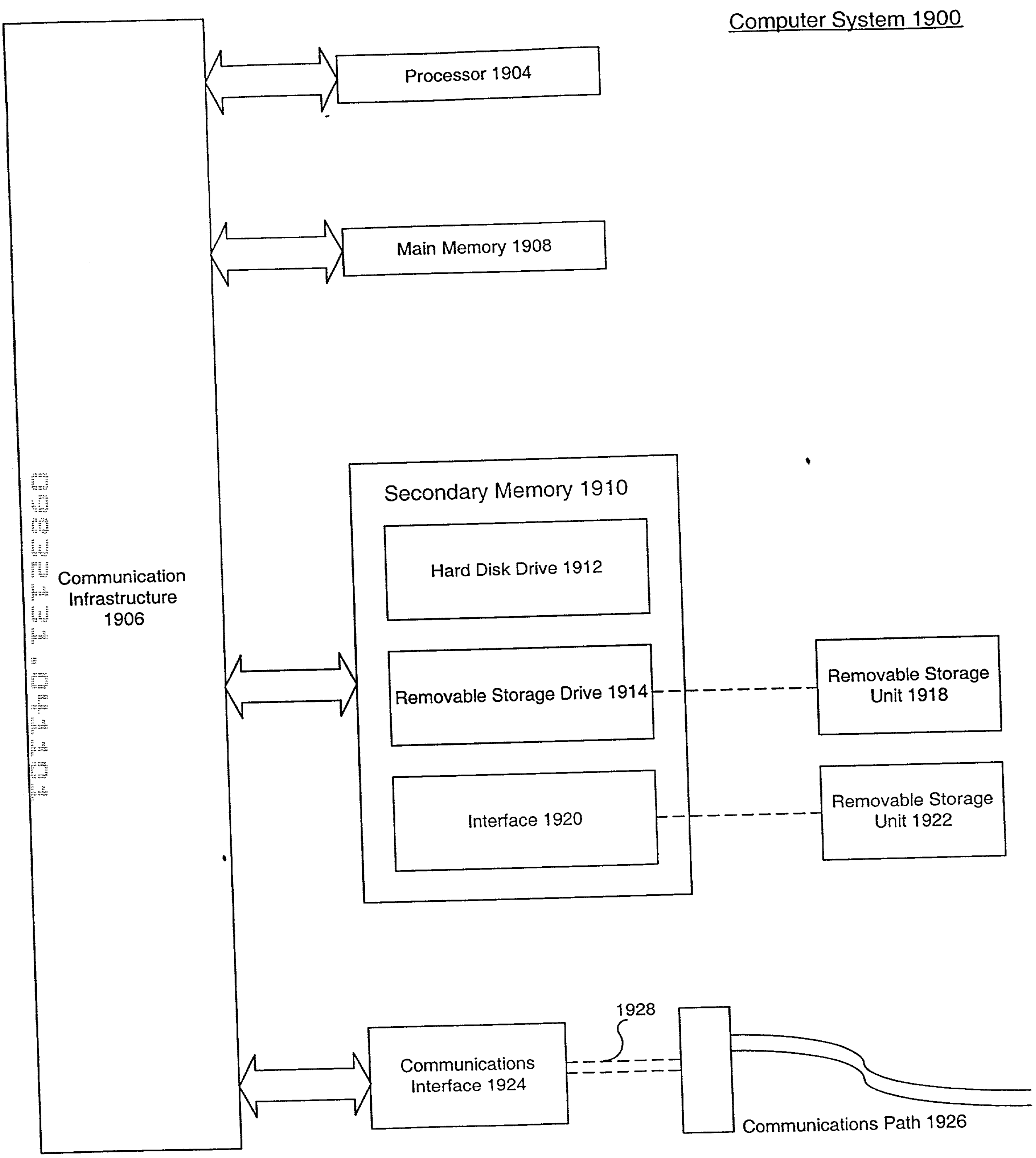

Computer System 1900
Processor 1904
Main Memory 1908
Communication Infrastructure 1906
Secondary Memory 1910
Hard Disk Drive 1912
Removable Storage Drive 1914
Removable Storage Unit 1918
Interface 1920
Removable Storage Unit 1922
1928
Communications Interface 1924
Communications Path 1926

FIG. 19